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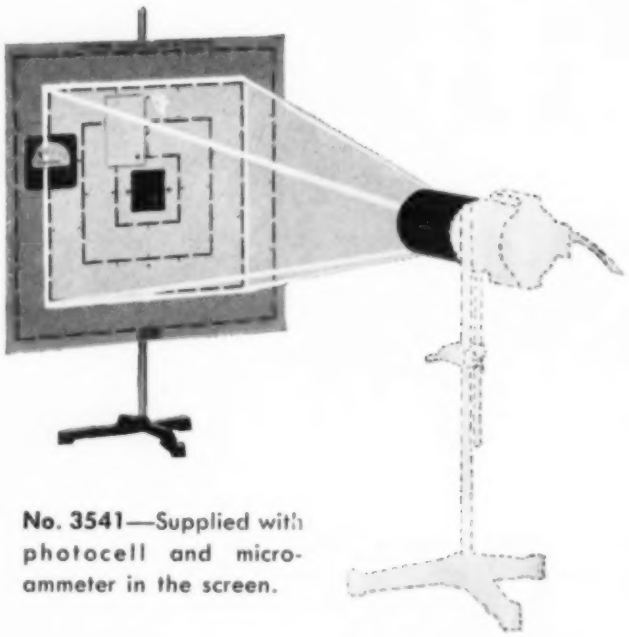

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By Wyndham D. Miles, Ph.D., U. S. Army Chemical Corps Chemical Center, Maryland.

Philosophical Aspects of Evolution II

By Andrew G. van Melson, Professor of the Philosophy of Nature, University of Nijmegen, Netherlands.

The Responsibility of Knowledge

By Robert H. Marchessault, Ph.D., Research Associate, Research and Development Division, American Viscose Corporation.

Problems in Photosynthesis

By Robert B. Gordon, Pennsylvania State Teacher's College, West Chester, Pennsylvania.

Medicinal Agents from Petroleum

By William S. McClenahan, Pittsburgh Section, The American Chemical Society.

The Artificial Kidney

By Fred A. Taylor, Pittsburgh Section of The American Chemical Society.

High School Calculus

• By J. H. Neelley
CARNEGIE INSTITUTE OF TECHNOLOGY

High schools are now giving college-level courses in mathematics and science, and in many cases students can earn advanced standing college credit in high school. All agree that this is a worthwhile innovation, but is it accomplishing its purpose?

Doctor Neelley has been studying the performance of students with advanced credit. In our June 1959 issue we published a paper on an earlier study by Doctor Neelley.

THE SCIENCE COUNSELOR is interested in the results of studies of this problem by both high school and college educators, both pro and con.

●

This paper reports additional experiences at Tech with freshmen who have had some high school calculus.

In September 1958 we had 48 freshmen arrive with high school calculus. Since only 6 appeared in 1957, we may assume the deluge is here and perhaps here to stay. Our experiences with the 1957 group were so unsatisfactory that we had adopted a new program. This program was to permit these bright students to do their regular four-semesters of freshman and sophomore mathematics in two semesters. We decided to try this, because they had had what *they considered* the equivalent of two semesters already and so we would review what they had had and do the other two semesters in the year 1958–59.

When the dean explained this to the 48, at once, 24 decided it was not for them. So, 24 were sent to the mathematics department to become a section with an accelerated outline of study.

The full Professor who was to teach this section explained in more detail what they would be expected to do and 8 more dropped out. To the remaining 16 he gave an examination similar to that given on two semesters of work, only a little easier. He reported that they had grades from 60% to 0% and only one 60% and 2 more dropped out. They seemed to be in the same condition as our weakest students who are given our lowest passing grade of D. The Professor reported that they knew a small amount of how, only some 10% of what we would like. That they knew no *what* and absolutely no *why*. What they did know was merely how to operate with the simplest functions and that only on stylized problems. Not one knew what a derivative was and less about the meaning of an integral. They could do practically no sketching of curves and so showed weakness in analytics also.

The 14 who stuck were from other parts of the country. No local products, I am glad to say. They were told that they could stay in this special section as long as they made good grades. A grade of D would mean that they could not remain in it. As of mid-term 3 of them were out.

The grades at the end of the first semester were fairly normal, but not high. One A, 5 B's and 5 C's. This 11 remained together for the second semester. Recall, however, that this is only 11 out of 48 who had had high school calculus.

It was interesting to see the attitudes of this group. They all assumed that they were very superior. Some knew more than the professor who was to teach them. Evidently they had kept their high school teachers in constant trouble. It took about two weeks to change their attitudes. Then, upon realizing their ignorance, their antagonistic attitudes became cooperative. Still more than 21% of those who made a try were lost.

These results make us conclude that high school calculus is largely a waste of time. If the brighter students must be given something above the regular high school courses, we suggest some analytics. The analytics of the straight line, the conics and some elementary curve tracing.

Above all, we, of the colleges, would like our students to be able to read. They come to us without the ability to read a text and understand it.

The future seems dark. We plan to repeat this year's experiment as we can find nothing that seems better. It is expensive. We question its advisability. They will keep coming. If you, of the colleges, try it, be sure to screen them well and keep a close check on how they are doing.

At the end of the 1959 year 10 of the 11 passed their first two semesters. Tech has grudgingly given them full credit for the equivalent of four semesters of analytics and calculus.

We have been forced into this credit giving by other universities having so done.

I am watching this group in their sophomore courses and will be able to report on how they do at a later date.

There are several things upon which we of the universities should agree. What shall we do about degree credit for an accelerated program? What shall we do about credit for high school analytics and calculus both for entrance and/or for advanced rating? Also what shall we advise the high schools *to teach* and what *not to teach*.

NOTE

This paper was presented on May 2, 1959 to the Allegheny Mountain Section of the Mathematical Association of America, and at Seton Hill College, to their N.S.F. Institute in July 1959.

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Philosophical Aspects of Evolution I

• **By Andrew G. van Melsen, D.Sc.**
PROFESSOR OF THE PHILOSOPHY OF NATURE AND SCIENCE,
UNIVERSITY OF NIJMEGEN, THE NETHERLANDS

This article deserves your serious study. It is taken from a paper presented at the Duquesne University Symposium on Evolution on April 4, 1959. The second part of this paper will be published in our June issue.

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The doctrine of evolution belongs to those scientific theories which have had repercussions far outside the field of science proper. The fact that scientific theories have these repercussions should not amaze us. Specialization may be a necessity in science, due to the abstract character of human knowledge, but behind the overwhelming variety of scientific methods and disciplines attuned to special problems, stands the unity of the human mind. The hidden motive of all human quest of knowledge about nature, about the material world, is the desire of man to know more about himself. Man wants to know his own origin, his nature, his destination, in short the meaning of his existence. For that very reason, even physics and chemistry, which at first sight seem to be sciences interested only in the structure of the material world around man, continually have given rise to discussions of a more general nature. In the past and present, physicists and chemists have claimed that their discoveries were of the greatest importance for theology, philosophy, psychology, sociology, etc. It is true, of course, that many times these claims have been proven false and that the scientists in question did not respect the limits of competency characteristic of their science. This, however, is not the issue at the moment. Important as it is to respect the proper boundaries between the different sciences, between science, philosophy, and theology, we should never forget that the different disciplines are not separated from one another by watertight compartments. The continual repercussions which scientific theories, rightly or wrongly, have had outside their own field clearly show that man in trying to understand nature first of all tried to understand himself, and justly so. For man knows that he, too, belongs to nature: nature is in him as it is around him.

What is true with respect to physics and chemistry, is still more true with respect to biology. In studying living nature, biology also studies man. Therefore, it is only natural that the theory of evolution, a biological doctrine, from the beginning has been tied up with philosophical and theological controversies about the position of man in the midst of nature. But apart from the general reason why any biological discipline has a close relationship with our quest of self-knowledge, there is a special reason why evolution has been so highly controversial. The theory of evolution may be a biological theory, but it is one of a peculiar type. It has a far-reaching aim—namely, nothing less than to explain the origin of life and man. It pretends to say something about this origin in a scientific way, and seems therefore an intrusion into the territory of philosophy and theology. Or should we say that, thanks to the doctrine of evolution, questions about the origin of life and of man ceased to be fruitless speculation and become open to scientific research and explanation? It is not very easy to decide which point of view is right, especially not because the theory of evolution could not immediately show its true nature. For, even considered merely as a scientific theory, apart from its possible philosophical implications, the theory of evolution has something of an ambivalent character.

As a rule, scientific theories are based upon experimental data, which all have in common that they can be repeated at will. Strictly speaking of course, no phenomenon taken as a whole can be repeated. This being so, experimental science must begin with analyzing the complicated concrete phenomenon in many aspects, each of which can be repeated. If I drop my pencil, for example, at this moment, then this fall is something unique for, as such, it can never be repeated. At least some of the circumstances will be different (e.g., the time-point). Yet, the pencil can be dropped again in slightly different circumstances, some of which will be important, while others are not. Instead of this pencil I can drop other objects of the same weight, of the same size, of the same or of different material and thus arrive at the general physical laws of gravitation. These laws, therefore, do not speak about my pencil as such, they speak only about objects with a certain mass, at a certain distance, and so on. Consequently, with respect to science, my pencil does not exist as a concrete object, but in a scientific context its concreteness recedes; as far as science is concerned, my pencil exists only as an instance of a certain mass, shape, color, chemical composition, etc.

With the general attitude of science in mind we easily see the special position of the theory of evolution. For evolution speaks about the origin of life as a unique event which took place in the past. In the same way its speaks about the origin of the various forms in which life presents itself. It contends that millions of years ago life originated from non-living matter (abiogenesis) and that by a process of gradual evolution the different forms of vegetative and animal life came into existence (macro-evolution). The other branches of biology, however, take it for granted that in the normal course of events life not only always originates from life, but also that the different generations always belong to the same type of being: horses procreate horses, cows cows, flies flies, and daisies daisies. There are undoubtedly slight differences between parents and their offspring, but these differences remain within the scope of a certain species (micro-evolution). For this reason micro-evolution can be studied by the biologist with experimental means, but not macro-evolution. We can sum up the special position of the theory of evolution by saying that abiogenesis and macro-evolution are not merely scientific, but also "historical" hypotheses. They have perhaps taken place, but biology is not able to verify them in an experimental way. We may add: it is not impossible that one

day the scientist will succeed in showing us abiogenesis in his laboratory. But even then he would only have confirmed the possibility of a natural abiogenesis in the past, his experiment will never confirm it as an historical fact. For science can never verify historical, i.e., unique phenomena, it can only verify repeatable events, i.e., it can verify the concrete only in an abstract way. History, however, is never interested in the abstract, but always in the concrete.

The above is not meant as a depreciation of the theory of evolution. On the contrary, it can be said that the historical character of the theory of evolution proves its importance, because the human mind is never satisfied with merely general and abstract laws about living nature, but also wants to know the origin of life in a concrete way. (In the same way scientists are not satisfied with studying the earth only as an abstract object, they try also to discover its cosmic origin.) Nevertheless, it remains true that the historical character of the theory of evolution is one of the main reasons for its peculiar status in biology. It makes it fall outside the scope of the normal experimental means of biology. From this it does not follow, of course, that the theory of evolution does not have any means at all at its disposal. What are these means and what are the reasons why biologists began to think in terms of evolution?

First of all there is more or less stringent geological evidence that hundreds of millions of years ago no life at all was possible on earth. For life can only exist within very limited physical conditions. Secondly, paleontological findings suggest that in periods when life was possible on earth, some forms of life which exist now did not exist. Thirdly, the different forms of life known to us can be classified in such a way that certain lines of development reveal themselves. Comparative anatomy, embryology, and physiology show that the same kind of structure underlies forms which at first sight seem entirely different. Therefore hypotheses can be proposed concerning the descent of one form from the other. Sometimes it can be concluded that formerly animals must have existed which are linked up with animal forms living nowadays.

Paleontological findings many times verified such theoretical conclusions. These facts show that the theory of evolution is not just speculation. Within certain limits, it can be verified by "historical" documents. Both the general grounds and the means of verifying the theory show, therefore, a more or less historical character, they confirm why biology can rightly be described as "natural history." To be natural history, however, is only one side of biology. It also wants to be a natural science. That is to say that biology wants to know the general causes of evolution. Why and in what circumstances did a new species develop?

It is mainly this problem which has given rise to many fervent discussions. Partly these discussions belong to the realm of science. As already stated, science can directly study only micro-evolution, that is to say, those differences which remain within the limits of one and the same species. Whatever mutations may have been discovered with the famous Drosophila, the pet-animal of geneticists, these mutations do not change a Drosophila into another type of animal. Consequently, the thesis that micro-evolution is caused by the same factors as macro-evolution—namely, random-mutation, selection, and isolation, is for the time being an extrapolation far beyond the realm of experimentally established facts. It depends, therefore, more or less on his belief in the reliability of this extrapolation whether a biologist thinks that macro-evolution is scientifically explained or not.

The discussions about the causes of evolution, however, are not wholly of a scientific nature, but partly also inspired by different philosophical positions. Especially in the nineteenth century it seemed as if a scientist who did not believe in creation was forced to believe in evolution. On the rebound, Christian philosophers thought that rejection of evolution was imposed by Christian dogma. This is the more amazing because till modern times Christian tradition had always believed in spontaneous generation, i.e., some kinds of animals were thought to be generated immediately from inanimate matter. Neither St. Augustine, nor St. Thomas, to mention only these two great founders of Christian thought, had seen any contradiction between the existence of spontaneous generation and the creation of nature by God. It is really one of the greatest mysteries of the history of thought that when in the nineteenth century the idea of evolution became generally accepted in the scientific world, many Christian thinkers thought that in the name of sound philosophy this idea had to be rejected. They even used the scientific arguments against spontaneous generation as evidence for their belief in creation! And apparently they had a strong case. After a long battle lasting several centuries, it became evident in the same nineteenth century which accepted evolution that spontaneous generation had to be rejected on scientific grounds. Thus we are confronted with the peculiar situation that it looked as if the advocates of evolution postulated abiogenesis on no other ground than that they wanted to avoid the idea of creation. Whereas there was some evidence for evolution within the realm of living nature, there was no evidence at all for abiogenesis. All the available evidence pointed in another direction. However, without abiogenesis there seemed no way out; the explanation of the first appearance of life demanded either creation or abiogenesis.

It would be wrong, however, to think only of a materialistic credo as the course of the idea of abiogenesis. For many thinkers this credo did play a role, but it is not the only reason and certainly not the main one why scientists advocated abiogenesis. They had a very sound philosophical reason which in itself had nothing to do with materialism, except that in the past so-called materialists did understand this reason better than other philosophers.

In order to see this reason, we have to dwell a moment upon a problem that dominates the history of biology and that is known as the antithesis between mechanicism (or materialism) and vitalism. A short analysis of this antithesis will teach us some important things about the nature of science and about the distinction between science and philosophy. It will also clarify much of the background of the dispute around evolution.

Mechanicism and Vitalism

The main point of the conflict between mechanicism and vitalism can be formulated in the question whether or not

all phenomena of life can be explained by purely physical and chemical factors. Mechanicists answer the question in the affirmative, vitalists in the negative. The latter think it necessary to assume that in any living being there is present a special factor, a *vital force* or *entelechy*. The still current term *organic chemistry* originated from that opinion. Organic compounds were believed to be formed exclusively in living bodies under the influence of the *vital force*. It would, therefore, be impossible to synthesize them in a test tube. Scientists, however, do not like the word *impossible*, especially when it is only the reflection of the empirical *status quo*. They always try to do the impossible.

In 1828 Wohler succeeded in synthesizing urea, and from that time on so many organic compounds were produced, that there was no longer any doubt concerning the possibility of synthesizing all organic compounds in the test tube.

However, that did not discourage vitalism. It could point at enough other aspects of living organisms to endorse its fundamental thesis that not all phenomena of life could be explained by chemistry. Famous are, for example, the startling phenomena of regulation and regeneration, studied by Hans Driesch. After a great number of skillful experiments, he pointed out that the development of a young embryo did not follow a deterministic course, but showed an adaptability to its situation which in his opinion could only be explained by the activity of a special non-material factor, the entelechy. It seemed as if an intelligent being directed the course of events in such a way that even under extremely favorable circumstances the embryo realized its purpose—namely, a harmonius adult animal. In emergency cases certain cells did not follow their normal development, but took an entirely different course in order to take over the tasks of damaged or lost parts. There could hardly be any doubt that the entelechy did exist.

Later experiments proved, however, that the intelligence of experimental biologists was much greater than that of the entelechy; it became evident that even the startling phenomena of regulation and regeneration could be explained by chemical and physical factors working in a purely deterministic way.

These two examples, taken from the history of biology, may suffice to make us understand the statement of von Bertalanffy; that the history of biology constitutes the refutation of vitalism.[1] And he is right, in so far as no biologist believes any longer that the phenomena of life cannot, in principle, be explained by physics and chemistry.

Does this mean, however, that the mechanistic point of view had won victory on all fronts? To answer that question, it should, first of all, be borne in mind that the general agreement among modern biologists with respect to the possibilities of physico-chemical explanations of life leaves one problem undecided. It is exactly the problem we are interested in—namely, the origin of life. All biologists do agree on the question that once the order of a living organism is given the phenomena of life can be explained by the co-operation of the material forces, co-ordinated in that organism. They do not agree, however, on the question regarding the origin of that order. Some consider that order as the unexplainable mystery of life, while others view it as the natural result of the material forces themselves.

Thus, the antithesis between vitalism and mechanicism is still alive. Both parties seem to have a strong case. The mechanicists claim that the history of biology will decide in their favor as it has done in the past, because they are convinced that the position they defend is fundamentally the same as the one they defended before. The vitalists point out that all actual biological explanations start and have to start with the given order of life. According to their point of view, physico-chemical explanation in biology can, to a certain extent, be compared with the way the working of a technical product can be explained. A technical product, e.g., an engine, works entirely in agreement with physical laws; given the construction of the engine, the engine must work as it does. That does not mean, however, that material forces explain also the origin of an engine—it owes its origin to the creative power of man. In the same way, the biological order could be based entirely upon material forces, without the latter being responsible for the origin of the biological order itself.

It sounds convincing and yet we should not be convinced too soon. For serious objections can still be raised against the modern vitalistic position. First of all, it should be pointed out that there is a great difference between a living organism and a technical product. The latter is the result of an artificial arrangement of material components. The parts of an engine are given a form which is not natural to them, the form is imposed upon them by an outside force. A living organism, however, for all we know, is built up with the aid of entirely natural macro-molecular structures, its form is not imposed from outside, but is the natural result of the structure of matter. This being so, it stands to reason that biochemists are interested in a new field of research, properly called chemical evolution. They try to understand how under natural conditions macro-molecular structures could be formed on earth and they have already found many interesting facts, as, for example, the entirely natural formation of amino-acids, which are important constituents of proteins. Although still much remains to be done in this field, the first results are hopeful for the mechanistic position. It seems likely that also the last fortress of vitalism is doomed to be surrendered. In that case the victory of mechanicism seems complete. But will it really be a complete victory?

With this question we have arrived at a point in our discussion which is of the highest philosophical importance —namely, precisely what conclusions should be drawn from the history of biology, as sketched above, which shows such a great victory for the mechanistic point of view? Should one of the conclusions be that we do not need the idea of creation any more, and another that there is no essential distinction between animate and inanimate matter?

As regards the first problem, it is not too difficult to see that the dispute concerning abiogenesis or biogenesis is of no relevance with respect to the problem of creation. For the question whether life is the natural result of complicated but normal material structures, a very special order of matter, or endowed with an entelechy in the neo-vitalistic sense, is entirely different from the question about

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They Make Textbooks Come Alive

• By John E. Bennth
AMERICAN FOREST PRODUCTS INDUSTRIES

"Good teachers continue to learn.

Well over 100 credit-granting workshops in conservation education are held each summer and the number is growing. Some, like the one described below, are held in remote scenic spots. Others are campus-based and devote several days to field trips. Instruction is enriched by experts in different fields of resource management. Information about 1960 workshops may be secured from C. W. Mattison, president, Conservation Education Association, 10014 Greenock Road, Silver Spring, Maryland."

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When childern come trooping back to school next fall, some of them will find their textboks more alive with the meaning of conservation—if their teacher is one of the hundred or so who signed up for a unique outdoor workshop course in Oregon last summer.

Now going into its sixth year, the Hoodoo Conservation Workshop, as it is commonly called, is attracting growing attention because it presents in a well-rounded "package" a study of the major elements of conservation—soil, water, wildlife and forests.

The setting for this integrated approach to conservation education is scenic Hoodoo Ski Bowl Inn high in Oregon's rugged Cascade Mountains. From here the workshop groups can make forays westward into the high-rainfall Douglas fir region or eastward into the semi-arid western pine country. They can climb to sub-alpine forests or make side trips to Oregon's lava caves and lava beds.

The workshop groups take numerous field trips so that staff instructors can demonstrate visually the complex interrelationship of woods, water and wildlife in nature's community. Here is a sampling of what went on at a typical forested stop last year:

Teachers disembarking from the bus flushed a startled deer from a brush thicket. Austin F. Hamer, education supervisor of the Oregon State Game Commission, explained how planned timber harvests create openings in the forest where browse for deer can grow plentifully. The group crowded around to get a close look at a tiny Indian Pipe, a rare waxy-white leafless herb which Dr. Ruth Hopson, workshop director and associate professor of general science at Portland Extension Center, found peeping from the forest floor.

They listened to the wind rustling in the tall Douglas firs while Arthur K. Roberts, education director of West Coast Lumbermen's Association, explained how foresters protect and manage timber like this in today's tree farm age to assure maximum, sustained-yield growth. Pat Wick, information officer for the U. S. Forest Service, explained the principles of multiple use and sustained-yield forest management.

The teachers peered into a soil pit dug several feet deep while Robert L. Brown, deputy state conservationist for the U. S. Soil Conservation Service, discussed composition of the soil at different depths.

By week's end, the teachers had acquired a growing new awareness of the complex balance of nature. They were coming to see nature as a community of soil, plants and animals which are dependent on one another.

They gleaned the specialized background experience of their regular staff instructors from fields in education, industry and government. They also heard from other resources people and specialists during the field trips.

The Hoodoo Conservation and Outdoor Education Workshop was first launched in 1955. Heavy financial support is given by the state's forest industries, both in direct grants to finance the project and through sponsorship of individual teacher scholarships. There is also participation by several soil conservation districts, chapters of the Izaak Walton League and other civic groups and industries.

Many of these scholarships are not restricted to local teachers, according to Robert L. Gridley, coordinator of the General Extension Division worshops, who handles requests for information from his offices at Portland Summer Session, Portland.

What do teachers think of this kind of conservation education?

The answers came out in evaluation discussions held at the close of the week.

Typical of these comments was that of one teacher who said he had many fears and prejudices concerning what he thought was happening in Oregon. Twenty years ago when he moved to Oregon, he said he saw evidences of "cut out and get out" in the forests. There was no visible sign, he said, of the teaching or practice of conservation in the schools. He thought private industry and state and national agencies did not know what the others were doing.

"I have since seen conservation come to the fore throughout the teaching systems in the state, and all this week I have had my eyes opened at the cooperation between resource agencies in their over-all plan of conservation." he said. "I couldn't believe it, though I have known of tree farms and other projects along this line in conservation. I believe this cooperation is one of the big things I have seen this week."

Another teacher said some students raised within forested areas take this wealth for granted without really "seeing" it at all. She said she feels far better prepared now to make her textbooks come alive with meaning.

Most teachers concluded that they could now put more meaning and better interpretation of conservation into the various courses they teach. One of them pointed out that little children are very receptive to the enthusiasm of a teacher, and that they are developing attitudes in many areas which they will carry through school and into later life.

"In my opinion we have, as teachers, a grave responsibility," she said. "It is a continuous challenge to be the kind of person which best represents life to its fullest. 'Since what we do speaks so loudly that others cannot hear what we say,' it is necessary for today's teacher to be an example of the good in life."

Another teacher put it this way:

"The most impressive and helpful thing to me is realizing the unification of different elements of conservation. The word took on new meaning and as the week progressed my sense of responsibility as a teacher increased.

"Some one said," she continued, "that conservation is a way of life. Our resources are to be used, but so used that we maintain a balance and that most people get the most good out of them. We must begin to educate our children to appreciate what nature has provided, and when we appreciate, the 'care of' will come."

The workshop had obvious utility for teachers of biology, social science, history, geography, even English and mathe-

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The Metric System and the United States

EXCERPTS OF REMARKS BY LOUIS L. STRAUSS, FORMER SECRETARY OF COMMERCE, BEFORE THE AMERICAN PHYSICAL SOCIETY, WASHINGTON, D. C., MAY 1, 1959.

Much missionary work by scientists and teachers is needed to make the general public aware of the need of a shift to the metric system.

The U. S. Department of Commerce National Bureau of Standards publishes a news bulletin, Technical News. *The following is from the May 1959 issue of* Technical News.

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I have long been convinced that ultimately the United States must shift to the metric system. Outside of our Anglo-Saxon culture, practically every nation has made this shift during the past 150 years or so. Every country found it possible to adopt the metric system—just as in earlier times we all shifted from the Ptolemaic to the Copernican system of navigation. No one ever regretted the temporary inconvenience of such switches. Due to our delay in taking action and due to the complexity of our industrial system, this change will be more difficult for the United States than for other countries, but when achieved it will also be more useful.

As civilization progresses, more and more people are compelled to do more and more calculating. Arithmetic and algebra could not become a tool of everyday life before Arabic numerals had been introduced. This was no doubt a painful change in its time but what enormous benefits resulted from it for all mankind.

The advantages of the metric system would be many in addition to ease of calculation and conversion. Most of our daily measurements would become more accurate. Bookkeeping and computational requirements would be reduced. Our international trade, our buying, and our selling, and many of our international aid and security programs would be facilitated. The metrological divorce between our science, research and development and our industrial programs would be overcome.

There is absolutely no doubt, the conditions of our times —the increasing importance of science for all phases of life as well as the increasing interdependence of nations through security, travel, communications, exchange, aid and trade— all require a convergence on one system of measurement.

The force of science and technology as well as the needs of the international economy will require the change. Science exerts an ever stronger impact on our society—and the language of science is couched in metrical terms. The more computer techniques come into significant use—and before this audience I need not predict the future role of such computational techniques—the greater will become our need for an efficient system of measurement.

The conquest of space will be facilitated if we first make up our minds to use the one measuring system which has the greater potential for growth and accuracy. This system will have to be the metric system because conversions in terms of feet per second become unmanageable for truly high velocities.

Actually, we are in error if we assume that we are using only the English system of measurement in the United States. At the present time, we are using both systems. There is little left of the English system in science. But the metric system also has been invading our daily lives. Slide rules and desk calculators are metric in nature. The decimal point with which we adorned the English system is an eloquent witness to the indispensability of the inevitable metric measurement. We switched from pounds and shillings to dollars and cents. In the chemical and electronics industries, the metric system is in widespread use. Our electrical measurements are all based on the MKS system. Perhaps it is significant to note that the pharmaceutical industry made its own decision to go over to the metric system in the past few years. This industry is one of the most forward looking. It is devoting a high portion of its sales to research and is actively engaged in foreign trade.

Think of the British pharmacist who deals in grains, drams, grams, liquid ounces, Troy ounces, cc's, pints, quarts, dozens, grosses, pounds, etc. At the end of each month, he has to close up for three days and construct a 14 x 14 transformation matrix to convert into pounds sterling, shillings and pence for his billings.

And, lest we forget, it has been medical practice in these United States to weigh all new born babies in grams—it must be the mother who determines little Johhny's weight in the English system by multiplying the grams by a factor of .002205.

Thus, the metric system is all around us. Providence has even given us 10 fingers on 2 hands thus hinting to us that the numbers 2, 5, and 10 are the natural units of measurement.

The problem, therefore, is not to make a revolution in measurement but to direct and accelerate the evolution which has been taking place. It is a matter of becoming conscious of this evolution and of giving it an assist. It is a matter of using the metric system more and more and the English system less and less.

Naturally this evolutionary process will take some time, —too much time if left to itself. But it might upset our economy to attempt to make the change by immediate decree. We still have very considerable amounts invested in the English system of measurement. Our culture has long been entrenched in yards, pounds, and gallons and a re-education will be necessary. Text books will require revision and instruments will require recalibration or replacement. The changes in our machine tools and in much of our equipment—containers for example—will be most difficult and costly.

I believe that some changes, especially of the large measurements, will be simple because they involve merely a matter of usage. There is no reason why we could not

start measuring distance in kilometers and heavy weights in metric tons. Also, you can keep track of your caloric transgressions in kilograms as easily as in pounds and far more easily than in stones as our British friends still insist upon doing.

It should not be too difficult to travel by metric maps and to sell and buy gasoline by liters instead of by gallons. The switch from inches to centimeters in industry will be more complicated. This change-over must be accomplished with minimal disruption. This means it must be accomplished with deliberation but I do not think it will take years upon years.

We simply cannot remain static but must recognize the conditions of our time and meet rather than be forced into the inevitable and logical. In giving recognition to the matter of accepting the metric system, I am saying that the time has come when the Government should do something affirmative about a proposal which scientists have been reiterating since the days of Lord Kelvin.

Recently a committee to consider the problems of shifting to the metric system was established by the American Association for the Advancement of Science after it had approved in principle the general adoption of the metric system of weights and measurements.

Our country had a number of opportunities earlier in its history to adopt the metric system and in truth it would have been much easier at those earlier dates. We could have adopted the metric system when we became a new nation. We had other opportunities when Thomas Jefferson and later John Quincy Adams considered our unwieldy problem of weights and measures.

Each time we delayed, the problem of a change became more difficult because we were becoming more industrially entrenched in our commitments to the English system.

As late as 1902, there was a good opportunity to shift to the metric system. At that time, Congressman Southard, who also introduced the bill which established the National Bureau of Standards, sought Congressional adoption of the metric system. It is an interesting historical note to reflect that the bill was supported by Alexander Graham Bell who was a good friend of Samuel W. Stratton, the first Director of the National Bureau of Standards and a strong advocate of the metric system. We are talking about events of 57 years ago.

Since that time, every year we have deferred the commencement of a program only to find the cost of the change-over has increased and that an orderly transition has become more difficult. What are the considerations that appear as though they will compel us to metricize ourselves?

They are of two kinds, scientific and economic. The advances in research in the past 20 years lead but to one conclusion as far as measurement is concerned. We must have an accepted world-wide language of measurement. We can no longer afford the luxury of national measurement systems which differ from those of the people with whom we want to trade.

Furthermore, the metric system lends itself most easily to providing an interrelated network covering all scientific fields. The fact that science is on the metric system and that civil engineering and industry by and large are on the English system makes for a great deal of unnecessary confusion and difficulty. This double system is costing us money, time and trade. I would not be surprised to learn that it is also hampering progress in other directions.

There are two compelling economic reasons for making the change. Our country is engaged in a broad technical assistance program to aid other nations in taking advantage of technology and raising their living standards. Our experts are finding considerable difficulty in dealing with systems foreign to their own. Many other nations are having difficulty with our instruments because they are labeled in the archaic English system.

I indicated a moment ago that the effect was being felt in the area of our foreign trade. We are beginning to be hurt by the fact that we do not produce and label our products in the metric system. In South America, in Asia and in Europe, we are meeting some resistance. Let me quote from the findings of the AAAS Committee on metric usage.

"We have discovered genuine concern (bordering on alarm) by experts in foreign trade over the failure of our manufacturers and packaging concerns to explain contents, dimensions and similiar items in terms of metric units in catalogs, specifications and on labels."

This finding is amply supported by the Bureau of Foreign Commerce of my Department.

Let me add to this point. We are engaged in a strong economic competition with the Soviet Union. It must be apparent to all that the uniformity of measurement systems between Russia and most of the world, including Western Europe, is an enormous advantage to the Soviets and a handicap to us. Further strengthening of the European common market will increase this problem.

Our country also has adopted a system of military aid to our allies and friends. The effectiveness of this program has suffered, I have little doubt, from the incompatibility of measuring systems. For example the NATO standard calibre rifle bullet is 7.62 millimeters (and I am sure that this does not hinder the ability of the European soldier to fire it). If you wonder why it is that calibre, try dividing by 2.54 and you will find out that some American or Englishman was loyal to his system out to five decimal places. However, our military experience—we are constantly changing systems—also indicates that basic transformations in our instrumentarium are feasible.

In brief, a dynamic country like ours where new commodities are adopted incessantly and where inventories are replaced periodically has the capability of executing a change in its measurement system. Our capability is not in question. What we need is a procedure by means of which the change can be carried out most expeditiously with the least cost, the least confusion and the least opposition.

There are, in addition, a number of other reasons favoring a change to the metric system. Such a change will eventually allow us to give better technical training in our

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Scientific Careers for Catholic Students

• By Daniel M. Lilly
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This paper was presented at the Pennsylvania Catholic Round Table of Science meeting at Immaculata College, Immaculata, Pennsylvania, April 11, 1959.

We recommend it as a guide for an educational examination of conscience.

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In the last few years there has been an increasing concern about the shortage of scientifically trained personnel in the United States. Our whole educational system both public and private has been subject to closer evaluation to determine whether we are producing the quantity and quality of scientists needed in the space age. Here at this meeting of the Catholic Round Table of Science I think we should consider what more can be done to foster scientific careers for Catholic students. We know that in the past there have been fewer American Catholics in science than we might expect. This is not strictly a scientific problem because we know also that our Catholic institutions of higher education have developed mainly in the last hundred years. Many of our Catholic colleges and universities began as seminaries for the education of priests. Later they began training young people for other kinds of work, but the parents who sacrificed to give their children a college education never thought of scientific careers. To them the greatest gift they could give their children was an education which would prepare them for the business world, the legal profession or the practice of medicine. Whenever a student turned aside from these established goals to become a biologist, chemist or physicist, it was usually an accident—and often lamented as such by the entire family who had expected better things of their children.

We can thank the interest in medicine, however, for the development of fairly strong science departments in most of our schools. As these departments prospered they eventually turned out their quota of science majors with Bachelor of Science degrees. Some of these were attracted to scientific careers.

For every student who turned to science, however, many others were discouraged by early impressions, often childhood impressions, of what they thought a scientist was. How many were influenced by the Hollywood version of the mad scientist? Or perhaps too many references to atheistic or agnostic scientists? How many were discouraged by the reputed difficulty of scientific work?

Fortunately the situation is improving slightly. High schools, and even elementary schools are including more science in their curricula. Catholic universities and colleges have increased in number and most of them offer good basic studies in science and mathematics. The problem now is to get more capable students to take these studies. Many parents have gone to college themselves or in any case are more aware of the variety of professions open to college graduates. Not so long ago few people knew what a physicist was—now if they read the newspapers they know that a physicist can take his choice of many well paid positions. Also more students and parents are conscious of opportunities for scholarships and fellowships. Most schools are doing more in career guidance and this is also helping direct capable students toward scientific careers.

In spite of the slow improvement we cannot afford to neglect the problem. For one practical reason it is getting very difficult to obtain qualified science teachers in our schools. More important than this, however, is the contribution we should be making to the scientific, intellectual and cultural advancement of our country and our communities. How can we justify our position if we neglect the scientific talent in our schools and let those who are so talented take up careers which are less of a challenge to their abilities and less beneficial to all concerned?

Not that we should discourage any student from his own choice of a vocation but when there are so many who have difficulty in making up their minds in high school and in college we can certainly afford to help them in making a wise choice. At every level we can help them to take as much scientific work as they can with profit. Of course it would be a mistake to encourage students who show no aptitude, but how many drop out of scientific work for financial reasons, for lack of confidence in themselves, for lack of appreciation shown by others. A career in science will never be easy and the higher a student goes, the more difficult it gets. The path of least resistance is for the student to stop while he is ahead—at the end of high school, with his Bachelor's degree, with the Master's degree or even to stop productive work after he gets his Ph.D. We may often find ourselves in the position to provide the motivation to make some students take that next upward and difficult step to achieve his full potential.

We have many ways of helping those who want to help themselves. Today there are many kinds of financial aids to help students, loans, part-time jobs, scholarships, assistantships, and fellowships particularly for students interested in science. We should know what these opportunities are, advise our qualified students and help them in any way we can to achieve at least as much as their fellow citizens. The National Science Foundation has many programs to aid science education. Our Catholic students have not been as quick to take advantages of these opportunities. Since one college student in ten is attending a Catholic institution we should expect about 10% of the fellowships to go to students at Catholic schools. Actually in the latest awards according to Father Yancey of the Albertus Magnus Guild there were about 3% awarded to students in Catholic institutions. This is better than one or two per cent we had in earlier years, but the fact remains that our students will not get the fellowship if they do not apply. Similarly, I know that many universities right now

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Salts of the Earth and the Sea: Their Needs By Man and Animals

• By J. F. Wischhusen
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This is a discussion of the ultimate sources of food for animals and plants.

This article is from a paper presented before the 26th Annual Science Conference, Randleigh Farm, Lockport, N. Y., September 19, 1959.

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Most sedimentary rocks are believed to have been deposited in the seas of the past. The question, what came first the salts of the sea or the earth? is comparable with the riddle of the hen and the egg. There is earth beneath the sea. Marine life is confined to the ocean or the lakes, but the quintessence of life, man, is the product of the earth, i.e. the lithosphere, the hydrosphere, and the atmosphere combined. Micro-organisms are present in all of these.

In an endless cycle the salts of the earth move from land to sea, in indirect courses, and when the water of the lakes or the ocean can no longer hold these salts in solution they settle out. Chemically salt consists of a metal that has combined with an acid, and as there are about 60 metals and many acids a great many salt combinations are possible. There are also compounds known as double salts that crystallize as one compound, but dissolve and ionize as two.

The composition of sea water has not varied substantially over untold years. This is attributed to the fact that oceanic plant and animal life remove many of the dissolved minerals carried into the ocean by rivers. When this sea life dies, the remains tend to sink, adding to the sediments. The composition of sea life is therefore not analogous with the composition of sea water. Similar differences exist between the composition of oceanic waters compared with the mineral composition of life on land. Thus man must obtain his supply of minerals from the earth as a whole.

The sea is often referred to as the cradle of life, but newer knowledge regards the sea shore as such. The International Oceanographic Congress recently received reports that the green areas of the open seas with abundant life are limited to those areas where a natural vertical circulation plows up nutrients from the deep waters to the sunlit surface waters. These nutrients are mainly dissolved minerals that foster the growth of phytoplankton and many floating microscopic plants. Sea vegetation is the result of growth in an inorganic medium, and such plants as kelp cannot be called "organically grown" as some food propagandists would have people believe. All sea water nutrients have their origin in the land. All primary food is produced by plants from earth and water with the aid of sunshine and the atmosphere. Earth is inorganic matter.

TYPICAL ANALYSES OF OCEAN SALTS
taken at random from "Data of Geochemistry" by F. W. Clark.

Chlorine, Cl. including Bromine, Br.	54.62%
Sodium, Na.	30.20
Sulfate, SO_4	8.01
Magnesium, Mg.	3.36
Potassium, K.	1.92
Calcium, Ca.	1.20
Phosphorus, PO_4	0.08
Iron, Fe.	0.08

THE PERCENTAGE COMPOSITION OF THE PRINCIPAL MINERALS IN THE HUMAN BODY
from H. C. Sherman's "Chemistry of Food and Nutrition."

Chlorine ..... as ash	Cl.	3.00%	in whole body 0.15%
Sodium	Na.	2.00	0.15
Sulfate ..... as	S.	4.00	0.25
Magnesium	Mg.	0.07	0.05
Potassium	K.	5.00	0.35
Calcium	Ca.	40.00	2.00
Phosphorus ..... as	P.	22.00	1.00
Iron	Fe.	——	0.004
		Nitrogen N.	3.00
		Manganese Mn.	0.0003
		Copper Cu.	0.00015
		Iodine I.	0.00004

plus traces of Zinc, Silicon, Aluminum Fluorine and other elements.

The use of sea water as a remedy for incurable diseases is not new. Prominent French physicians and other scientists have demonstrated miraculous cures in infants and adults with sea water. Many such cases are referred to in a recent book by Marie Mauron, entitled "La mer qui guerit," (the sea that cures), edition du Seuil, 1957, Paris VI. in which the author reports her own recovery from arthritis and rheumatism. Equally interesting results are reported in the literature to have been secured from the therapeutic and nutritional use of the minerals from the Pacific Ocean, salt from the Gulf of Mexico, saline spring water from the Shenandoah Valley in Virginia, and from various mixtures of soluble salts. They contain mostly the chlorides of sodium, magnesium, and potassium, plus substantial amounts of sulfates. Calcium and phosphorus are generally minor constituents, but an array of trace elements is often reported present in sea salts in minute amounts to which great therapeutic values are attributed. In the experience of the writer over the last thirty years, trace elements when found deficient, must be supplied in concentrations and ratios commensurate with the shortages that accumulated over prolonged periods, and in forms that are compatible with the daily diet. Although existing from conception and birth, deficiencies of many trace elements remain unrecognized, because the symptoms thereof do not manifest themselves until later life. It must also be borne in mind that essential trace elements are required by all forms of life, including pathogens and parasites, so

that doses are needed in concentrations that are toxic to such detrimental organisms, before they can be of benefit to their hosts. Furthermore trace elements are metals that are known to be protected from hydrolysis by organic complexing, which complexes then become metabolized and and precipitate. So instead of looking upon sea water for a supply of trace elements as nutrients for humans, they are deposited on the sea bottom, from which they may be recovered in times to come as salts, oxides, ores, etc.

The following are the elements generally found in ocean waters in minute amounts: iodine, fluorine, bromine, arsenic, silicon, boron, lithium, rubidium, caesium, barium, strontium, aluminum, manganese, nickel, cobalt, copper, zinc, lead, silver, gold, radium, and they are therefore conceivably present in sea salt. But any claim for their nutritional value cannot be substantiated, because measured doses and certain ratios are required to correct any deficiencies in the human and animal bodies.

The general use of common salt, sodium chloride, in processing modern foods, and its addition to meals at the table, would seem to preclude its deficiency in human diets, but rather be responsible for a dietary excess of sodium, if not chlorine. Studies of both animals, and the diets of differnt populations has led Dr. Lewis K. Dahl of the Brookhaven Laboratories to conclude that too great a salt intake can be harmful. Nevertheless we know of at least one case in which rheumatism was corrected with sodium chloride, never to re-appear again. It would be a fallacy to practice a saltless diet, because sodium and chlorine are major elements essential to life. Experimental sodium chloride defiiciency in man has been studied, and is described as anorexia (loss of appetite), nausea, fatigue, a sense of exhaustion, and muscle cramps. As would be expected there was hemoconcentration. All such manifestations of the defiiciency disappeared following the ingestion of salt and water. Those advocating the regular use of sea salt must bear in mind the heavy consumption of common table salt that already takes place. To balance this daily salt intake requires food supplements of magnesium, potassium, sulfates, and calcium phosphates. Dr. Hans Selye, Director of the Institute of Experimental Medicine at the University of Montreal says that two simple salts, magnesium chloride and potassium chloride may be helpful for the prevention of heart disease and disorders of other viscera. Reports from users of these compounds bear this out.

SALTS FOR LIVESTOCK. In previous papers before this conference reference has been made to the excessive use of common salt and calcium carbonate in feeds for livestock. This no doubt contributed to a deficiency of magnesium and phosphorus. The former is reflected in such incidences as tetany, staggers, irritabilities, and chemical irritations often taken for mastitis; the latter causing hoofrot, sterility, and depraved appetite. Trace elements have also been the subject of many papers. Their inadequate presence in commercial feeds as well as home grown fodder is aggravated to a large extent by constantly higher production goals. Thus the emphasis on feed supplements concern the use of more phosphates in relation to calcium, and more magnesium in relation to sodium plus adequate amounts of trace elements in correct and harmonious proportions in relation to such special objectives as disease resistance, reporduction, and other performances. The trace elements now regularly, but promiscuously used in commercial feeds are. iodine, manganese, iron, copper, cobalt, and zinc, with a borderline need for molybdenum, arsenic, vanadium, nickel, fluorine, and selenium constantly under investigation. The effects from the use of all of these appear to be enhanced, and the danger of toxicities reduced when they are furnished in correct ratios first among themselves, and secondly in relation to the total consumption of good roughage, and not excessive amounts of proteins that contain all essential amino acids. After all the herbivores and especially the ruminants' economic value lie in their ability as intermediaries in food production to convert non-food products of the soil into foods for man.

The sulfates, nitrates, and potassium among themselves and in relation to magnesium, calcium and phosphorus present recurring problems in the way of bloat, tetanies, milkfever, etc. Extra nitrogen demands extra potassium; extra calcium demands extra magnesium and phosphorus. In this respect the soil and the weather play unpredictable roles, so that the studies of nutrition and veterinary medicine require correlation with the studies of soil science and plant nutrition for a common goal of better animal and human health. Plants are of course not mindful that they exist to supply ideal nourishment for the higher forms of life that consume them as feed and food. Their nutritional quality undergoes many changes from season to season, from locality to locailty, and from harvest to consumption. To obtain from such variant factors a balance of nutrients for optimal results in the way of good animal and human health and production requires the constant attention of the feeder and the food consumer. This may be achieved by suitable feed and food supplements which in turn must be based on food requirements as compared with food composition. The adoption of standards for optimal food values has been advocated in a paper before the 25th annual conference at Randleigh Farm.

Plants will of course forever take from soil, air and water such nutrients as are within their environments for either poor or high quality feed and food. Thus the factors that made healthy plants thousands of years ago are still the same today, and will remain so for all times to come. By the same token the health of animals and man will forever be governed by the nutrients in their feed and food, and the secrets of health lie in the individual who is healthy. Since there can only be one optimum of the total of all nutrients required for the health of either man or animal, the frequently advertised new and better, even "scientifically discovered" materials for combatting diseases, or for good looks and longevity, are admissions of the shortcomings of previous offerings, not alone of food and feed ingredients, but of therapies, drugs, vaccines, not forgetting tranquilizers and cosmetics. As a prominent theologian aptly put it: we have 350,000 laws on our statutes to enforce ten commandments. So we seem to be compelled to study that many enzymes, viruses, hormones and other end products when there are but 92 atoms that compose the earth, and about 65 essential elements or nutrients that compose our bodies. An Indian philosophy commends itself too:

"Indian build little fire, keep warm;

White man build big fire, keep warm hauling wood!"

Teleology and Science

• By Rev. Charles J. Schaeflein
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"The heavens tell the glory of God, and the firmament proclaims the work of His hands." Psalm 18:2.

This paper was presented at the Pennsylvania Catholic Round Table of Science meeting at Immaculata College, Immaculata, Pennsylvania, April 11, 1959.

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Today more than ever there is a great stress placed on more effective teaching of science in our educational system Sputnik has ushered in an era of soul-searching and breast-beating, unparalleled in our history. Our country's educational system has been undergoing a very close scrutiny by committees and experts from the Congress down to the local P.T.A. "We must have more science in our schools—we need better science teachers—we must interest more students in science courses." While there is some truth in all these statements, we must not assume that the mere accumulation of scientific facts by a greater number of our citizens will answer all our problems in this complex world of ours.

The Russians admittedly emphasize science with several purposes. They recognize the value of science itself, but at the same time, they do not miss the opportunity of using this same knowledge as an instrument for conveying their philosophical principles, namely, atheistic materialism. Science is also an instrument of their national policy.

As Catholics we also have a philosophical outlook on life. We have an interpretation of science over and above the mere study of science as science. Although we acknowledge that science gives us a more accurate knowledge of the world we live in, at the same time we see science as an instrument for revealing the design and order that the Creator put into the world. As teachers of Catholic youth we have an obligation to place teleological aspects before our students. Failure to point out the deeper implications of the organization and unity of scientific knowledge is to half-educate the student.

We are committed to educate the whole man. This means we cannot teach our students a mere mass of facts divorced from a world outlook. We must integrate their knowledge into a meaningful whole. Science must be supplemented by a philosophy.

A person who knows nothing but a science is not necessarily a well-educated person. His knowledge of science must fit into a larger scheme and help to explain the meaning of his existence. Scientific knowledge is limited knowledge, confined to one segment or reality, and as such cannot satisfy man's urge to know Truth Itself.

We have an obligation to show our youth facts in some perspective. We must present them a pattern or philosophy of life. They want to know "why" as well as the "what" of life. The pertinent question for Catholic high school teachers is, "Will this total view of the universe which the student is formulating be Christian or will it be secular?'

There are many scientists who are philosophical, positivists, empiricists, or just plain materialists. They feel that there is only one valid method for finding truth—and that is my induction, experimentation and observation. These methods are certainly able to reveal a wealth of knowledge about the quantitative aspects of matter. If that were all there is to the physical universe, just matter (whatever matter is, we don't know) then we would agree that these are the perfect tools for learning all there is to know about reality. A materialist is necessarily a monist. All reality is material and subject to the objective tests scientists set up. They cannot admit of any non-material element in the universe. They deal only with atoms without quality There can be no entelechy or psyche in matter, or anywhere in the universe.

The notion of purpose or design must naturally be opposed by these men since it introduces into a materialistic world an unacceptable, unprovable force or power. These scientists often object to the use of teleological language, or anthropomorphic language as they sometimes call it. In the December 1958 issue of "Science," A. J. Bernatowicz, a member of the Botany Department of the University of Hawaii, complains in an article that teachers should refrain from using "non-rigorous" language in science classes. Most examples of teleological expressions are found in Biology texts, but some are also found in chemistry, physics and even astronomy. He objects strenuously to statements expressing a goal or purpose. For example: "Most green algae produce flagellated or amoeboid reproductive cells whose *special purpose* is to function as gametes." "One *purpose* of food is to act as a fuel for our bodies supplying us with heat and energy." Beware he says of the use of the infinitive—it usually denotes purpose. "Seeds are modified *to* function as agents in the distribution of the species." Here the infinitive "to" signifies purpose. In astronomy texts he finds this statement, "Each of these rotating rings of gas would condense to form a planet." Mr. Bernatowicz would substitute the word "and" instead of "to." Then he states: "The danger is not that we teach unscientific terminology, but that we are actually thinking teleologically and communicating these modes of thought to the students." "It would seem that we have a predilection for those modes of thought." It would appear then that we have a natural aptitude for using teleological expressions, yet Mr. Bernatowicz would impose an artificial form on us making us use expressions which ignore our natural reasoning processes. Does he not see purpose working in all the myriad examples in nature? He states, "Rare indeed is the student who will explain why a salmon swims upstream in mechanistic terms." Does Mr. Bernatowicz imply that there is only a mechanistic explanation for this phenomenon? If he wants to explain this complex activity as merely a series of chemical actions having no relationship to egg laying he may do so. If the exhausting activity of swimming upstream and over waterfalls has no causative link with spawning, the salmon certainly should evolve a less arduous series of activities that just happen to precede spawning.

Order and purpose are certainly found in nature at every turn. So obvious is this purpose and order that we must make a deliberate, conscious effort to avoid it. It is the boast of scientists that they are *objective*. If this is so then they must reckon with the natural tendency of the human mind to ask the question: "why?" It is not content to ask "what." *Science is objective:* It may come as a shock to scientists to discover that recent developments in science prove that science is really subjective. It was physicists like Plank, Bohr, von Weizsaecker, and Heisenberg who made man aware of this. Especially the development of quantum physics made clear that the ideal of absolute objectivity and of an absolute objective view of the universe was a dream never to be realized. Recent discoveries taught convincingly that every so-called scientific view of the world is extremely limited. Every scientist who approaches the universe selects necessarily one out of many viewpoints which could be taken. It is essential that the scientist does not look on man and the universe in all their dimensions, but that he limits himself to a selected part of the universe. This selection is based on a choice and on assumptions which are relatively subjective. Thus scientists must fractionate the universe and study it piece by piece. We have chemistry, physics, geology, minerology, astronomy, physiology, endocrinology, histology and zoology. These scientific ways of knowing man are forced to reduce that which is given in primary experience to a limited and subjective view. What are considered to be objects in science are not objects which are given as such, but which are viewed in a specific frame because man orients himself subjectively in a certain way towards reality. Naive experience does not know about the objects of science but knows people, houses, birds, trees, flowers, love, hate, and anxiety. When man determines subjectively that he will consider all these realities in a scientific way, then he limits his experience of them by some subjectively created frame of reference. They are no longer what they were. So-called exact data are rather interpretations of man's primary experience. Science modifies experience fundamentally and it does this by means of a subjective choice by man. The scientist selects the aspect under which he will consider reality, and this subjective choice always starts from certain assumptions which cannot be proven scientifically.

Chemists must assume there is a constancy in nature—a fundamental order present which assures us that H_2O will produce water (I am prescinding now from Deuterium and Tritium). One does not have to sample every drop of water in the world to know that water is composed of H_2O. This knowledge is based on incomplete induction. We assume that this combination is true everywhere in the world and even throughout the universe. In a world of pure chance we could not have that assurance. But if not chance then design, purpose. We don't put the order in the world, our formulae merely expresses what is already there.

You might gather from all this that I am anti-scientific, but I assure you being anti-scientific is not one of the requirements for being a Catholic and especially a priest, as some people think. I am merely trying to say that we must beware of *scientism*. A creed or philosophy which would try to invalidate any knowledge that cannot be verified by the experimenttal method. I think the expression they use is—it has "no meaning."

You have a philosophy of life. You recognize forces in nature, especially in man, which cannot be explained on a physico-chemical basis. There is a pervading order and design in the universe which is not explained by the random juxtaposition of atoms. Allow this viewpoint to enter your science class, not as science, but as something beyond science. It is a unifying knowledge, a philosophy which tends to give meaning to the whole picture.

If you are discussing the wonders of a living cell, remind your class that science has not discovered the cause of life. And even though scientists do learn the mechanics of protein formation up to the level of protoplasm they cannot explain the origin of the elements out of which the proteins are formed.

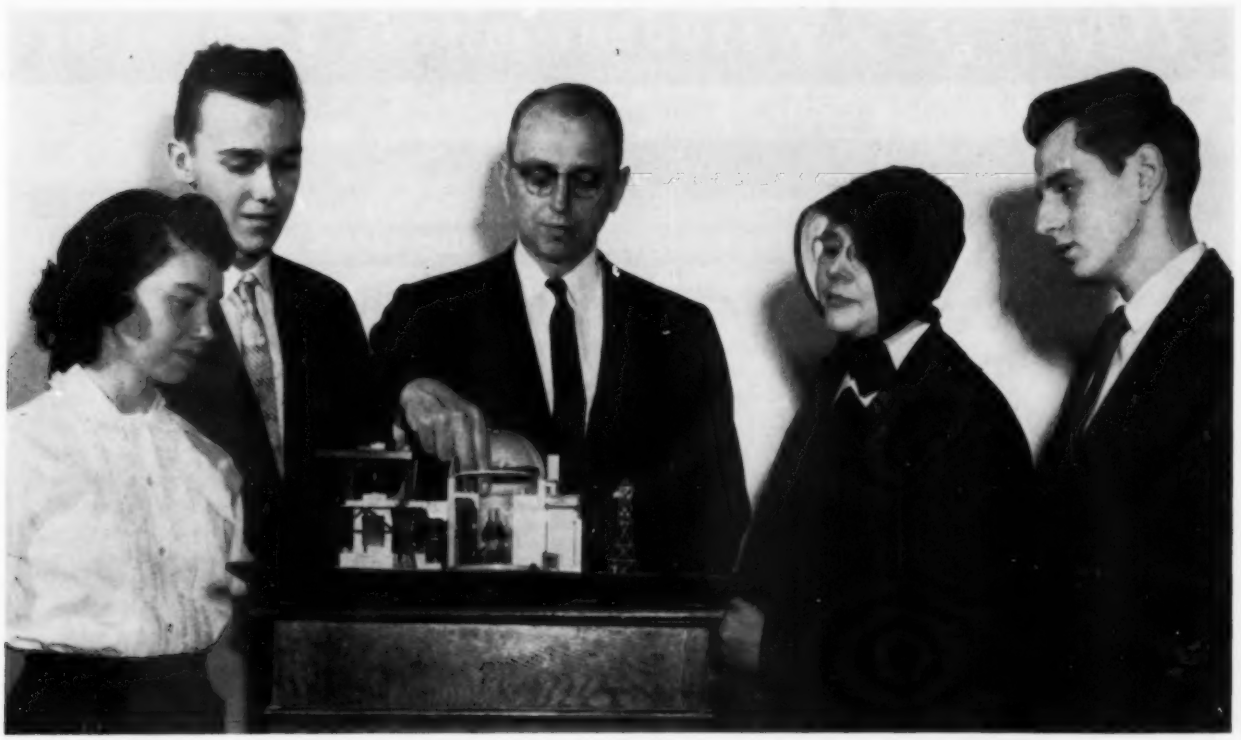
If you are discussing the marvelous adaptations in animals, remind the class that the animals didn't decide on these adaptations themselves. Instincts (a word covering our ignorance) are not explained by chance—these actions are intelligent and purposeful. One of the difficult problems in evolution is the explanation of the origin of instincts.

All of us teaching science have many opportunities in our courses to point out instances of design or purpose in nature. There are many eminent men of science who would be the first to agree that the world is not self explanatory—that there is a directive force or mind behind the physical world. The deeper they study the more humble they become. On the other hand, we have men like Huxley, who states, "the universe is a mud pie made by two blind children, matter and force."

I would add a note of caution, however. I would not like to see the science class turned into a religion class. We must seek explanations in nature first—natural causes or laws are the means by which the primary, First Cause operates in the universe. Appeals to the supernatural do not explain phenomena. I am, however, saying that the marvels of the natural laws we discover reflect the supernatural.

I would like to conclude by quoting a poem which is found in the back of our diocesan Biology Laboratory book—a book so well done by the Sisters of St. Francis. It is by Cale Young Rice and goes like this—

"There is a quest that calls me
In nights when I am alone,
The need to rise where the ways divide
The Known from the Unknown.
I mount what thought is near me
And soon I reach the place,
The tenuous rim where the Seen grows dim,
And the sightless hides its face.
I have ridden the wind,
I have ridden the sea,
I have ridden the moon and stars,
I have set my feet in the stirrup seat
Of a comet coursing Mars.
And everywhere
Thro' the earth and air
My thought speeds lightning-shod.
It comes to a place where checking pace
It cries 'Beyond lies God.'"



Pittsburgh Diocesan science students were challenged recently by a Westinghouse atomic scientist to investigate engineering and scientific careers in his field. William H. Hamilton, an atomic scientist since 1950, told the 400 members of the Science Honor Society representing the top science students of 40 Catholic high schools a definite need exists for such talents in atomic power. In addition, he said that the field has a great deal to offer in the way of individual opportunities for technically trained people. In the photograph Mr. Hamilton who is manager of the Pressurized Water Reactor project at the Bettis Atomic Power Laboratory near Pittsburgh is using a model of an atomic plant to explain a point made in his presentation before the group at St. Anselm High School in suburban Pittsburgh. Looking and listening are Carole Atler, Elizabeth Seton High School, Pittsburgh; Leonard Chapla, St. Anselm High School; Sister Francina, S.C., moderator of the St. Anselm science honor group; and Robert Lazdy, North Catholic High School, Pittsburgh.

★ ★ ★

The Metric System

(*Continued from Page 9*)

schools because of the relative simplicity of the system. Many scientists and engineers are witnesses to the waste of effort on conversion tables and in daily laboratory conversion procedures.

We have noted difficulties resulting from the confusion set up by the use of both systems. For example, American pilots landing on a foreign landing strip face such difficulties. At times, such difficulties are translated into truly hazardous situations. In other instances, we publish metric data in one publication and English data in another which is wasteful duplication.

For certain areas of our economy, the change-over would give no apparent advantage. For other areas, an abrupt change-over would prove very costly and time-consuming. In land measurement, for example, surveys and titles are based upon a network of reference points, divisions and sub-divisions in the English system, and it may take scores of years with the American title history as it is to convert them to a metric classification; and problems such as this may exist in other fields, but there is no need for instant and immediate conversion in these circumstances. In many areas, on the other hand, the change could be carried out with little or no trouble.

I am sure most of us here in this room share the conviction that the eventual change to the metric system is inevitable. I am sure that most of us are aware of the cost and difficulty of such a change. But we have no choice but to analyze the problem and look for a rational solution. I believe we ought to begin promptly to study it and to see whether a plan can be developed for an orderly and effective transition.

There will always be those ready to convince the gullible that something terrible will happen if mother tries to mix the baby's formula in the metric system. But invariably after the desired change, everybody is readjusted and forgetful of the dire effects which were supposed to occur.

Accordingly, I propose to request the Director of the National Bureau of Standards to establish an advanced planning group to assemble all available documentation and to identify possible courses of action.

(*Continued on Page 26*)

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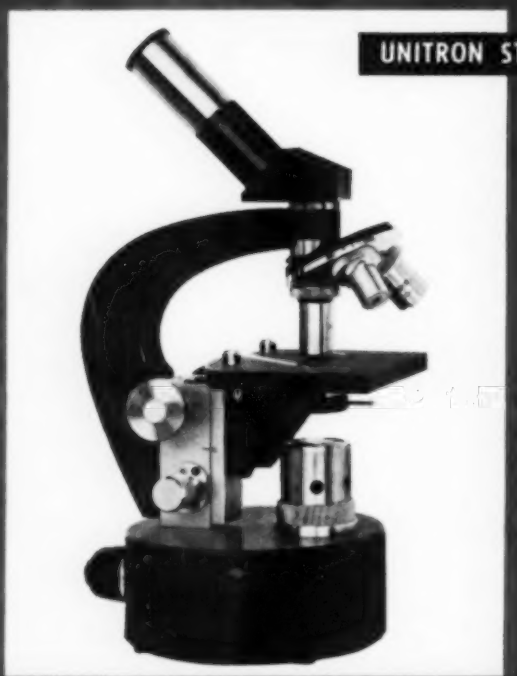

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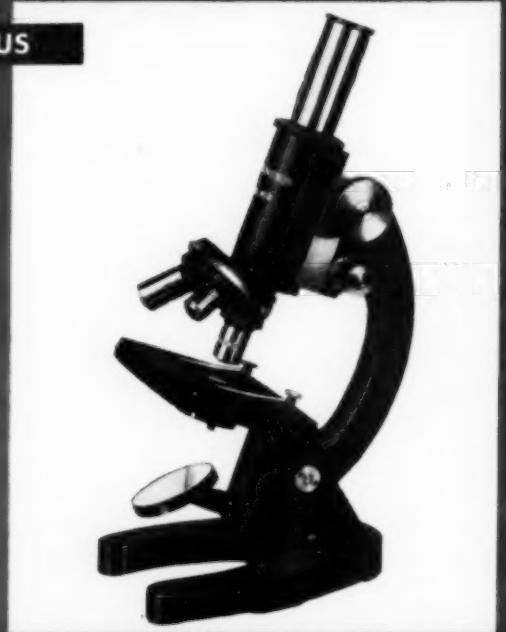

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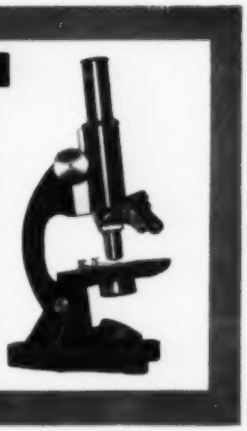

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Tomorrow's Scientist and the Liberal Arts College

• By Dale C. Braungart, Ph.D.
CATHOLIC UNIVERSITY OF AMERICA, WASHINGTON, D. C.

How effective are our present programs of higher education?

Are we training or educating our future scientists?

The author discusses the fundamentals upon which answers to these and similar questions must be based.

●

We cannot discuss to any profit the scientist of tomorrow without recalling certain admitted facts about the scientist of today. And these facts, in turn, rest on facts of the past —some of them of the not too distant past—which have conjoined to make him what he typically is. Admittedly, the representative scientist has some splendid virtues such as enormous industriousness, methodological exactness, patience and detachment in the pursuit of facts, cautiousness in combining what facts he establishes, willingness to start all over again when his laboriously won hypotheses collapse. He has not a monopoly of all these excellences but they stand out, and deservedly stand out, in the public's image of him. But at the same time he is felt to be overspecialized, to be ill-equipped intellectually as a human being and citizen in present day Western society and ill-equipped to wrestle with the larger problems of science which his very successes as an investigator have thrust upon him. Howsoever oversimplified such charges may seem to be in specific cases, there would be little justification for discussing the scientist of tomorrow unless there was much substance in these charges—enough, at any rate, to given concern to educators in and outside of science.

The scientist, however, is not basically different from other human beings. We may appreciate his condition better and plan better for his future, if we recall certain well-established facts which help to explain him. These facts may be listed as follows:

1. For a long time Western society was indifferent to him.
2. Later and for a long time it was hostile to him.
3. Out of this hostility developed the great and unnecessary dichotomy between faith and reason; the hostility of one to the other.
4. Because of this hostility modern science developed outside academic walls in great scientific societies, without benefit of philosophy and theology.
5. It fell into Cartesianism and the Newtonian physics with enormous, superficial success indulged in the illusions of exact measurement in areas where it is not appropriate and in the illusions of the all-sufficiency of science, mechanistically conceived, as well as the illusion of progress.
6. With Rutherford, Clerk Maxwell, Bohr and Einstein, and their like, and with what two world wars have taught us, the illusions of several centuries have been swept away, but faith and reason are not yet reconciled.
7. And this difficulty of reconcilement has increased because of the progressive narrowing of the scope of the typical scientist's inquiries.
8. These inadequacies have been aggravated by the fact that the English and American colleges which should prepare students for the university have begun to be serious institutions only within a very few years.
9. These inadequacies have been aggravated in America by the American love of tinkering and technology and the corresponding horror of theory.
10. They have been aggravated by the tendency to premature specialization in colleges to satisfy the narrow concepts of medical schools, scientific schools, graduate schools, and the quest of industry for specialists to fit temporary needs in their assembly-line organization.

The foregoing is an attempt to cover schematically an immense amount of wrong-headed history from the Renaissance down to our own day. I wish to pause for a few moments over certain significant items in this long and mournful list—items which are still much with us at the present time.

Until recently the American college has failed as a liberal arts institution. One of our basic needs as a nation is a generally educated citizenry, for the success of our democracy depends ultimately upon the wisdom of our people. Yet this crucial need for liberal education, that is, the kind of education that will prepare men to deal with the problems which confront all members of a society like ours, as well as those he will meet in his professional career, has been largely overlooked at the higher levels of education in this country. This is especially true because we have been concerned with more restricted needs—our interest in developing immediate rather than long term competence for occupations and professions. There is no disputing that our law schools, medical schools and engineering schools have developed efficient programs of preparation for everyday professional practice; and the academic departments of our universities have become expert in producing specialists. It is even possible to advance students from the realm of elementary training directly into specialized fields, without providing for the development of the wisdom concerning the common problems of mankind which members of a democratic society need to acquire and which any scientist needs to acquire in order to meet the new and unexpected which always confronts the professional man who is more than a routine mechanic. Having failed to develop this wisdom, we are known to complain about the indifference or lack of intelligence of the American voter, and we are

often discouraged by the blind and unreasoning ways in which national policies are formulated. We bemoan the low state of our national culture as revealed by the movies, the television, the radio and the comic books. We may even be alarmed by the evidence of scientific illiteracy as exposed in the success of pseudo-scientific quackery and the obviously false advertising so common today, and the professions bewail the scarcity of the scientist who can *think* in terms of his profession.

One of our great needs, particularly for the scientist, therefore, is the development of effective programs of higher education. No one has to prove that liberal education is a good thing. The proof is easily found in the number of high schools throughout the land that are trying to give general education to every and all levels of intellectual material. The high school, in order to accommodate this immense wave of youth, has declined as a college preparatory school and has become a melting pot—a stop-gap between grade school and the technological institute. Students are being amused for four years in order to keep them off the streets and out of their parents' hair until such time as they become of 'age' for the more serious business of making a living. As a result even the so-called college preparatory program has suffered major dilutions. This may be partly due to the enormous increase in enrollment of the high school student body, the lack of adequate facilities for teaching scientific and other disciplines, the inability to staff these over-bulging high schools with properly trained and dedicated teachers. Biology, physics, chemistry and mathematics courses, particularly, have degenerated into watered-down excuses for pretending to teach the scientific methods under the titles of general science and mathematics. The difference in the content method and purpose of courses labeled science or mathematics is so great and often contradictory that there is little hope left that the student, either apparent or real, has actually been exposed to science at all. The colleges, in spite of their inadequate preparation, are expected to look to these educational mills for their own crop of freshmen and to turn out men of wisdom who have previously had no challenge to their intellect and who have coasted through four years of an educational mill. This, then, has contributed to our failure as an institution of higher learning and has accounted for the rise in numbers of technological colleges and non-academic courses which have seeped into the curriculum of the liberal arts college oftentimes under the pseudonym of survey course, the elective system, and the major.

Science and the Liberal Arts

At present, man feels a passionate urge to dominate nature and exploit the resources of the material world through scientific knowledge. We have reached a stage in which it is necessary for man to become familiar with scientific notions that are producing our mechanized civilization. If educators are intersted in having their students capable of adapting themselves to their own times, they must find the means for students to acquire at least some elementary training in the sciences and the scientific method. Some students will resent the addition of science to their program which is already rather heavy, but little do they realize how inadequately they will be prepared for living in a rapidly changing world should they be deficient in scientific education. We are constantly and more loudly being informed that America needs more scientists. If this is true, we must

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decide what kind of scientists we really do need. Shall our future scientists be technological automatons or scientists with a broad and liberal education, trained in the specialization of their choice but so trained, so educated that they can look beyond the present level of their specialty and contribute to its advancement, so trained that they will be able to examine systematically the meaning and the purpose of their work in the light of all the other social and economic problems confronting man today. There are some who feel that the future belongs to the nation with the best technical brains; that technology will assure economic and political power; that our conventional methods in encouraging students to choose science as their life's work are inadeqaute; that it is urgent for the needs of defense to emphasize science above everything else to maintain our dwindling supplies of necessary metals and fuels; that it is a question of quantity (that is, more courses in science) rather than quality (that is, more theory). Is our relative inferiority in the sciences due to the attitudes of former years; or is the recent and special importance accorded to the sciences being resented by educators in our colleges and universities? The former may be partly true because our liberal arts colleges were under the misapprehension that science did not fit into a liberal arts program because of the very historical nature of its development. But it is recognized by leading schools today, that science itself if taught with the proper approach and with the liberal arts attitudes can and is as much a liberal arts subject as philosophy or history.

Let us briefly examine the role of science in the liberal arts college. The development of the modern university has been opposed to liberal education and chiefly through the mechanism of departmentalization. Even though this kind of development has virtues there is no doubt but that it has been inimical to a liberal education. It is true that departmentalization has aided and promoted the development of precise disciplines; encouraged provisions for expanding research; made available to more students the opportunities of specialized knowledge and techniques. But while these are virtues in themselves and for the specific reasons of creating specialists, the practices have discouraged the student from becoming interested in a well-rounded education which would develop the whole man and the scientist so that he can deal wisely with his own problems as a scientist and those of the entire socio-economic system of which he is a part.

What is a Liberal Education?

However, the failure to realize what a liberal arts training in our day means is slowly giving way to complete understanding. The initial difficulty is a conflict in the minds of educators as to what is meant by a liberal arts college. Some believe that a liberal education means concentration in what are often called the humanities. Although it may be impossible at any time to secure unanimous and detailed agreement concerning what is essential for every student to acquire in college, there is a general agreement that a liberal arts college ought to provide all students with the means for acquiring, and demand of all students evidence of having acquired, the understanding of society and its social institutions, the knowledge of the physical world in which they live, and experience with the methods employed by the natural sciences, competence to understand and

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appreciate literature and the arts, the ability to express themselves clearly and effectively which all members of our democratic society, regardless of occupation or profession, ought to acquire, and the experience of knowing some one subject well. These seem to be the components of a liberal education—the kind of education man needs as a man in a society of other men rather than as a specialist and a competent scientist.

All that remains in effecting these general purposes is to define them precisely, to discover what they involve and to formulate in the particular instances a plan to achieve them. The development of a college curriculum consisting of an integrated system of courses covering the major areas of knowledge rather than a collection of departmental courses is no mean task. A sound college curriculum is not simply the product of historical accidents but must be based upon a sound educational philosophy. What is taught, how it is taught, the inclusion of one subject rather than another, the choice of one method of introduction over another—unless these are to be explained simply as the persistence of tradition or unthinking limitation, will reveal by implication the philosophy of education which a faculty holds either consciously or unconsciously.

A well thought out college program must consider the nature and needs of the students, the extent and character of the knowledge accumulated in western culture, the role of the college in the social order, and the interests and training of the available faculty. But fixing upon one or the other of these as a guiding principle to the exclusion of all the rest may lead to an unfortunately one-sided curriculum. A liberal education cannot aim at developing in the student a high degree of competence in a narrow field because competence must be an enduring thing and a critical thing; a capacity to be ready for change; a firm grasp of the fundamentals which because they are fundamentals do not change, coupled with a capacity, so to speak, to roll with the punches which changes in the field produce. This experience may come from concentrating in English or Greek; it can also come from concentrating in a science, if the science at the college level is viewed as a liberal arts subject. This experience is the best of all possible preparation for graduate work and future training in a profession.

A few years ago, emphasis in college was on obtaining specialization in a scientific field to the exclusion of, or at least de-emphasis of other disciplines, and with emphasis upon the present level of that science, which was inevitably in the process of being outmoded. Where this kind of curriculum exists the undergraduate is actually receiving an undergradcate professional degree of an old fashioned kind, worthy of a mechanic rather than a scientist, which was one of the reasons for awarding the B.S. in the first place. The B.S. degree once was a Bachelor of Science in chemistry, or physics, or biology, while an A.B. degree was awarded in the humanities. And the training in science, being the technological thing it was, deserved to be thus marked off from the humanities. The early universities first granted the B.S. degree as a concession to the sciences of the time but as an inferior degree, to prevent any confusion with the more dignified academic title of the A.B. The B.S. degree as originally granted was a specialized degree whereas the A.B. was strictly identified with a liberal education. Slowly, the B.S. program became less a training in technique and in some colleges as much a liberal arts

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program as one in philosophy or letters or languages. If a college grants the B.S. degree today one may legitimately ask "What actually is meant by the B.S. degree?" The B.S. supported by other symbols, for example, the B.S. in Nursing Education, B.S. in Mechanical Engineering, B.S. in Electrical Engineering, is a legitimate undergraduate degree signifying to all the world that it represents specialization at the undergraduate level, and ofttimes efficiency of a high order in a particular subject. Today, however, the scientist of tomorrow needs the kind of liberal education which I have tried to suggest in the preceding paragraphs.

What is Science?

Science is above all else a way of solving problems—not all problems, but a large group of important and practical ones. The problems with which science can deal successfully are those subject to the basic laws of logic and which are for the most part measurable. It is a way of organizing reproducible knowledge about such problems; a way of focusing and disciplining the imagination; of weighing the evidence; of deciding what is relevant or not; of testing hypotheses impartially; of ruthlessly discarding data proved to be inadequate or inaccurate; of finding, interpreting and facing facts and making those facts of nature the servants of man.

The essence of science cannot be found in its outward appearance, in its physical manifestations. It will be found in its inner spirit. The importance of science lies in its austere but exciting technique of inquiry that has become known as the scientific method. That method requires its disciples to have high standards of personal integrity, an open-mindedness and sharp vision, heightened by the love of truth. But although these are solid virtues, science has not an exclusive lien on them.

The solving of logical and quantitative problems by the scientist have given evidence of noteworthy progress. And their successes have been so many and so striking that in spite of their less publicized failures, the average man has come to believe that science is the most spectacularly successful enterprise of man. It is true that man has, to date, succeeded in solving a large number of relatively difficult problems but the hardest ones and those which promise most for his future, still lie ahead. We must stop thinking of science in terms of its spectacular successes in solving these simpler problems; among other things we must stop thinking of science in terms of gadgetry, as a kind of modern black magic capable of accomplishing anything and everything.

Every scientist is confident that science is capable of further contributions to human welfare; that it can continue in its march against physical nature, learning new laws, acquiring new power of forecast and control, and of devising new material things for man's use and convenience. It can also make further contributions to a more complete understanding of animate nature, giving man new health, longer and more effective lives and a wiser understanding of human behavior. The precise, objective and analytical techniques of science may even find useful application within limited areas of the social and political disciplines. Better than any other discipline, science has solved the problem of communicating ideas and has demonstrated world-wide cooperation and community of interest and purpose.

Education of the Scientist

Although science is a powerful tool and has enjoyed an impressive record, the humble and wise scientist does not expect nor hope that science alone can do everything. The liberally educated scientist, and he must have had training in college that is liberal and not special, will have respect for any special competence and will not be deluded into believing that every social, economic or political emergency can be automatically dissolved by placing any "scientist" in control. Our democratic society demands of him recognition of and concern for values and purpose so that he can achieve a balanced good life in which logic is the companion of beauty and efficiency is the partner of virtue. Science alone cannot furnish the yardstick for measuring nor the motor for controlling man's love of beauty and truth, his sense of values, and his convictions of faith. These are rich and essential parts of human life which are alogical, immaterial and non-quantitative in essence and which cannot be seen under the microscope, weighed with a balance, nor determined by a sensitive electronic machine. These are the things our democratic society will demand of him as a citizen and which he can only hope to achieve even to the slightest degree through a liberal education.

The general or liberal education of the scientist is more urgent than the education of the humanist in the sciences—more urgent because first, because of the increasing emphasis on science and their greater number today; second, because of their increasing responsibilities; and third, because of the nature of a liberal education itself. Nothing is so ambiguous as the last. Granted that it embraces a variety of interests and skills, it also includes the ability to think and talk about the problems of life and of society and to make logical judgments in a variety of fields including science itself. This may arise spontaneously from an education that is non-scientific but is less likely to do so in science alone because of science's tendency to specialize.

How can we modify the specialist education of the scientist so that we can produce the whole man and the whole scientist we desire? The problem is filled with difficulties. The most frequent method is to insist that the scientist study some field unrelated to his specialty, but there is no guarantee of the broadening effect of a subject that is not science. The requirement that everyone study Latin or Greek has no broadening effect at all, unless they are approached as any other subject ought to be approached. As emphasized before, the approach of the non-specialized as well as the specialized subject is of prime importance. This will depend upon the training and interest of the teacher who must be a stimulus in educating the student to read, listen to music or look at pictures for himself.

The liberal education of the scientist should include religion, for science and religion are mutually helpful, and not antagonistic. Some of the best work in science has been done by deeply religious men like Mendel, Pasteur and Janssen. Science has been an important instrument in destroying superstitions, some of which have been theological; others, however, scientific superstitions. Religion promotes law and order in a civilization in which scientific progress is possible. They can and do implement each other in the mind of a liberally educated scientist who becomes conscious of the fact that there can be different

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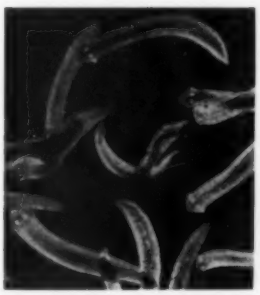

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kinds of science and that at best they promote only good order and that understanding is a result of his entire philosophy without which his science has no meaning or purpose.

The study of science was once reserved for a small number of select students but today it is tending to become an integral part of every student's training. In its beginnings the study of science may be entirely factual but as the years progress new facts are accompanied by explanation and the concept of theory can be gradually introduced as a basis for generalization. The careful examination of theory and experiment will develop the critical eye, introduce the necessity for logical thought and exercise of the intellect. Today, the development of the natural sciences has progressed to such a stage that, in general, a specialist is one who is trained in a specific branch of science whose knowledge of other branches may be only fair and whose knowledge of other sciences alarmingly meager, and whose knowledge of still other branches of learning may be completely void. This condition of current science has resulted in a science major desiring to become a specialist as early as possible. That attitude is unfortunate for in such early specialization the student loses the perspective of science as a whole as well as its unity, resulting in the loss forever of any philosophy of the scientific method. On the other hand, by examining the historical development of science, its growth and diversification leads logically to that which is fundamental to all sciences—the scientific method can illustrate the means of probing the wonders of nature, of the humanities, languages, philosophy and theology as well as the experimental sciences.

The student interested in the scientific method does not need to be invited to participate in this challenge to his intellect. By nature he is curious and therefore it is natural for him to consider the flowers in the field and the birds in the air, the stars in the sky and the rocks in the earth. As teachers we cannot make a student learn what he does not wish to learn, but our purpose will be betrayed if we neglect the scientific studies in our system of education. The study of the natural sciences is needed to complete the intellectual development that is partly derived from literature, history, logic, religion and mathematics. Familiarity with the cold, hard facts of science, the rules of the experimental method, especially as practiced in biology and physics today is to become familiar with the workings of the human intellect at its best. The student will learn that matters not passing the test of experimental verification are not to be spoken of with hesitation and that he should not be induced either by himself or by others to mistake probabilities for fact. Scientists themselves do not always distinguish between what they really know and what they merely suppose to be true.

The colleges stand between the high schools from whence its students come and the graduate schools where they will go for specialized training. The function of the high school is to lay the general foundations of education while the task of the graduate and professional schools is to train specialists. The objective of the college is to prepare young people to deal with the common problem confronting all members of the society of which they are members. This is an important and difficult assignment since it rests on the assumption that they will teach the future citizens of America to think—an achievement which will have its

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effect upon the future domestic and international policies of an America which is made up of its citizens.

In America our specialized training has been more or less successful in the development of gadgets, drugs, and mechanized tools for our convenience. Criticism of the American system of education is not uncommon for we are accused of allowing other nations to get ahead of us in the fields of technology which is often confused with science. Books, magazine articles, editorials, and forums advocate more emphasis on science as a vital component of education for "democracy," for "peace," for "tomorrow." All over the country, in committees of scientific and educational societies, not excluding the Presidential Committee and even the local parent-teacher organizations, this is becoming a favorite topic of discussion.

Our ultimate aim in science should be concerned with more immediate goals. Our concern should be with the role of science in the life and culture of man for tomorrow, which is directly linked with the role of science in the liberal arts college of today. Arguments are heard for the revolutionary reconstruction of the American system of education to produce more specialists in technology and science, an argument based on the achievements of the U.S.S.R. In the liberal arts college we are not concerned with the educational practices of the Soviet Union for our objective in America is the fullest development of each individual as a free human spirit—not as a slave of and for the state and as a scientist. Those of us who think this way believe that an education that is liberal, as it should be in our colleges of liberal arts, is the means to that end whether it is accomplished in the humanities or the sciences, to resurrect for a moment the old dichotomy. What is required for the scientist of tomorrow is that better science be taught to all students and not only to those planning a career in science. It is not enough for the student of science to know his particular field well but provision must be made to enable him to know why he is doing what he does and what the social, economic, and religious results will be. The ideal scientist of tomorrow will not be half a man, a man with a single competence, which may be in the process of being out-moded, the man awake only when his special ability is challenged, but a whole man capable of serving the nation and his fellow man through leadership rather than being led into serving it, and through being an inspirative and creative scientist. One Einstein or one Bohr is worth a multitude of mediocre technologists no matter what their diploma reads. They, like the von Braun's of today, are distinguished from the mediocre scientists by a power that specialized education cannot give—a power of imagination to which a liberal education is dedicated. The American liberal arts college and university should not alter its purpose in science or any other field of knowledge on the basis of priorities set up by a defense department but should encourage science to flourish under the flag of theory and imagination if we hope to produce the leaders in science tomorrow from the youths of today. What we really need is not a different kind of education but a better education of our own kind.

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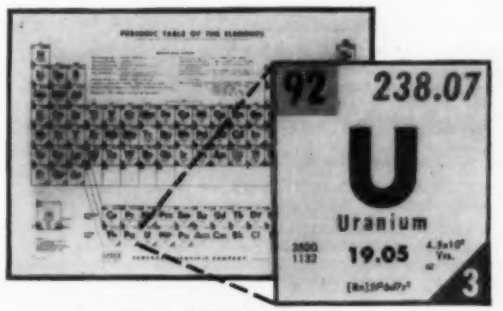

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The Metric System

(Continued from Page 15)

Through our advisory committee's contacts with business of all sorts, we will establish special industry committees to tell us of their special problems, and within the Department the problems will be studied with a view toward determining, among other things, whether Government activities can be metricized and whether there are special legislative requirements which must be satisfied.

Your own views and suggestions as individuals would be most welcome, and I hope that you will address me.

The work of the existing AAAS Committee on Metric Usage will receive the important consideration which it deserves, as well as that of the parallel committee of the British Association for the Advancement of Science. We will examine the experience of India and Japan in the fairly recent shift to the metric system in those countries. This should pinpoint for us some of the problems involved in such a change-over. Japan's experience would be especially pertinent since that country faces a number of advanced technological problems similar to those faced by us.

If there should be a parallel committee in other countries using the English system, we would want to make our studies cooperative in order to insure continued effective cooperation and the avoidance of duplication.

In the meantime, the National Bureau of Standards will continue its extensive program of providing calibration services in both the English and the metric systems. The calibration system of the Bureau will be expanded and services in both systems will be available as long as any important segment of our society requires calibration in either system.

One recent improvement in the English measurement system was announced last winter by all of the national standards laboratories of the English-system-using nations. I refer to the agreement to define the inch as 25.4 millimeters, thus removing important minute discrepancies in the inch definitions of different countries. This agreement conforms to the recommendations of the American Standards Association and of the AAAS. This uniform and simplified definition of the international inch will provide for better measurement in communication between English-speaking nations, and because there is now an agreed mathematical relationship between the English system and the metric system, will make it easier to move from the English to the metric system.

In the meantime also I hope that a number of industries on their own will study the problem of converting to the metric system and advise us on their examination. Wherever possible I hope that they will take voluntary steps towards the effective transition to the metric system as has the pharmaceutical industry. I am fully aware of the lead times that may be required and the other problems that must be solved. But industry and science can contribute to the solution of these problems and I hope this will be done.

AO Reports on Teaching with the Microscope

Husbandry of Molds or Gentleman Farming in the Classroom

By: Mr. William Altfeld
New York School of Printing
New York, New York

This unique experiment is reproduced exactly as submitted by Mr. Altfeld. He has used it, with much success, in his general science classes at the New York School of Printing. We submit it to you as a fine way to introduce students to the study of microscopic common, non-green plant life, as well as to the importance and use of the microscope in biology. In a very simple way, it extends the field of microscopic creativity by utilizing ordinary, "everyday" materials...indeed, the dust from the very air that surrounds us.

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EXPERIMENT

Growth and microscope study of our common molds.

MATERIALS AND PREPARATIONS

1. AO Spencer No. 66 Compound Microscope with 10X eyepiece and 10X and 43X objectives.

2. A microscope lamp is also a worthy accessory.

3. Box of clean slides and cover slips.

4. Tweezers and teasing needles.

FOR THE MOLD CULTURES THEMSELVES

1. Thoroughly cleaned food jars with twist off caps e. g. those used for jam, peanut butter, mayonnaise etc:

2. Squares of stale bread (cut down to 1″ x 1″);

3. Newspaper;

4. Water;

5. Normal dust from the air.

PROCEDURE

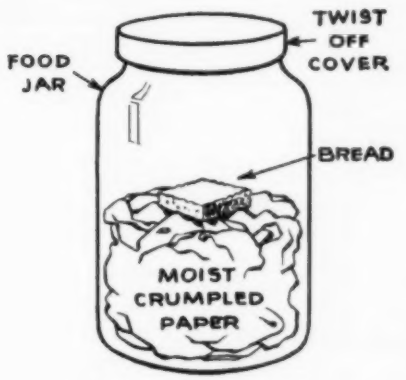
1. Crumple a small handful of newspaper.

2. Sprinkle (do *not* soak) the newspaper with water until it is damp, but not limp.

3. Place the ball of damp paper into the bottom of a cleaned food jar (Fig. 1). With the cover on, this will provide a moisture chamber essential to the germination of mold spores.

4. Take a 1″ x 1″ square of stale dry bread and rub one side of it along a dusty surface of a table.

5. Carefully insert the square of bread into the prepared jar with the dusty side up.

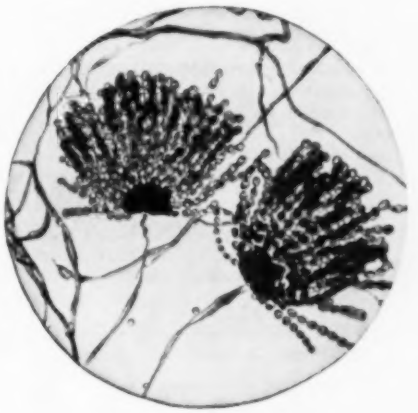


6. With the cover of the jar replaced, the culture is now placed in a dark, warm, part of the room for several days.

7. A variety of colorful molds may be the reward for the careful mold gardener. However, the most common bread mold, Rhizopus nigricans ... a black mold with cottony mycelia will tend to steal the show.

8. After the molds have made their appearance, we can open our jars, and prepare to delve into the tiny world with the microscope.

9. With tweezers we snip off a sample of our common black mold. Place the sample on a clean slide into a drop of water. With teasing needles we separate the mass of hyphae. Then we prepare a temporary mount with a cover slip.



Photomicrograph of an Aspergillus

10. We now examine under 100X of the microscope for an over all view of the hyphae with their spore cases. Under higher power, 430X, we can observe the myriad spores which will have escaped their spore cases.

OBJECTIVES

The beginning students of biology will be able to appreciate the following facts:

1. Instructive experiments may be done with simple materials found in the home.

2. Molds do not originate from decaying matter, but rather from tiny "seed-like" spores, which themselves, germinate on decaying matter, and aid in that decay.

3. Mold plants are of many varieties just as our higher green plants.

4. The microscope is an essential tool in the understanding of the reproduction and growth of tiny plants.

Success with simple experiments may arouse students to try many others and so maintain an active interest in the science of life.

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• *Edited by* Morris H. Shamos. Henry Holt and Company. New York. 1959. Pp. 370. $6.50.

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The experiments are printed with very wide margins and the margin is used for notes to explain the text. This makes it easy for the novice to understand the text without cluttering it up with useless detail that the initiated do not need.

This book can be recommended as supplementary reading for a terminal course in physics or for advanced courses.

J.P.M.

Spectrum: The World of Science

• *Edited by* Ray Ginger. Henry Holt and Company. New York. 1959. Pp. 116. $3.95.

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In addition to the main articles, William James' chapter on "Stream of Consciousness" is reprinted with commentaries by modern psychologists. All articles are beautifully illustrated with pictures and diagrams which add to the clarity of the text.

We recommend this book for use in both college and high school library.

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Crucibles: The Story of Chemistry

•*By* Bernard Jaffe. A Premier Book, Fawcett Publication, Greenwich, Connecticut. 1960. Pp. 240. $0.50. (Paper).

There is a great need for books such as *Crucibles: The Story of Chemistry* to destroy the distorted picture of the man of science that has been created by the authors of science fiction and motion picture script writers. The reader of this little book will learn that scientists like any other similar group are made up of all classes of people, and that they can not be placed in any particular classification of personality, temperament, or physical appearance.

Bernard Jaffe, by means of a series of well selected biographies of famous alchemists and chemists, presents not only a survey of the history of chemistry, but also an accurate picture of the men responsible for its development. It is easy to read and can be read with profit by the high school or college student who is interested in knowing more about both the scientific and human aspect of chemistry. We can also promise the professional chemist who reads this book a pleasant evening.

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Harper Torchbooks

• Science Library, Harper and Brothers. New York. 1959.

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In the history of science these three important works that can be recommended to both scientists and students in the humanities. They do not require the depth and background needed to read Watson and Eddington but are all important works in the history of sciences. **Readings in the History of Science** by William and Margaret Dampier ($1.50) is a selection of readings on three aspects of the history of science: (1) the structure of the universe, (2) atomic theories, and (3) evolution. Each section is made up of selections from ancient, medeival, and modern authors and while each selection is an independent unit, they are so organized that the reader obtains an accurate picture of the development of our present concepts. The section on cosmogony starts with Aristotle and ends with the theory of relativity. The atomic theory is introduced with a selection from Lucretius and closes with Sir Ernest Rutherford. Aristotle, Pliny, Darwin, Mendel, Morgan and several others are used to present the theory of evolution. This is a very informative and fascinating book. **A History of Science Technology and Philosophy in the Sixteenth and Seventeenth Century** by A. Wolf (two volumes $1.95 each) is a fully documented study of the sixteenth and seventeenth century developments in science which does not neglect the concurrent developments in technology and philosophy. The author makes extensive use of the works of the famous men of this period and quotes them rather extensively. The result is that the reader not only becomes acquainted with the developments of this period, but obtains a realistic picture of the whole background of these centuries. The book is attractively illustrated with drawings many of which are taken from the original work of the author cited. In addition to being scholarly the book is easy and pleasant to read. **Science Since 1500** by H. T. Pledge ($1.85) is the most complete one volume work in the field. The subtitle is a short history of mathematics, physics, chemistry and biology. The author has chosen to divide his work into chapters based on the major advances in a certain area of science or mathematics, a method which is more satisfactory than a mere chronological narrative. The book is well indexed by subject and by authors and as a result it can be used as a handy reference book.

Introduction to Mathematical Thinking by Friedrich Waismann ($1.40) is a book that should be in the library

of every high school and college teacher of mathematics. In view of the current trends in mathematics, this discussion of the basic concepts in mathematics is most timely. It does not require a profound mathematical background but will require studious reading.

Albert Einstein: Philosopher—Scientist edited by PAUL ARTHUR SCHILPP (two volumes $1.95 each) is a most interesting work both from the point of view of the picture of Einstein it presents, and also as a document portraying the development of science since 1900. Twenty-five scholars from all over the world have contributed articles on many aspects of Einstein's career as a scientist, philosopher and man. Volume I opens with a autobiography by Einstein, and volume II closes with a criticism by Einstein on some of the views expressed by the various authors. A most interesting 800 pages.

Philosophical Aspects

(*Continued from Page 5*)

the existence of the material universe as such. Even if all phenomena of life can be reduced to the original forces of inanimate matter, still no answer at all is given to the problem of the origin of matter itself. The latter is an entirely different problem. Therefore, G. G. Simpson is quite right in his book "The Meaning of Evolution"—which strongly defends the mechanistic point of view (he even calls it the materialistic view)—when he writes: "Yet the origin of that cosmos and the causal principles of its history remain unexplained and inaccessible to science. Here is hidden the first cause sought by theology and philosophy."[2]

From these considerations it should be clear that the antithesis between mechanicism (materialism) and vitalism has several aspects, and that more than one problem is involved. First of all, the scientific problem whether or not the phenomena of life can be explained by physical and chemical methods; secondly, the philosophical issue known as the problem of creation and, thirdly, the problem of the distinction between inanimate and animate matter.

1. L. Von Bertalanffy, *Das Biologische Weltbild*, Bern, 1949, vol. I, p 21.

2. G. G. Simpson, *The Meaning of Evolution*, New York, 1951, p. 135.

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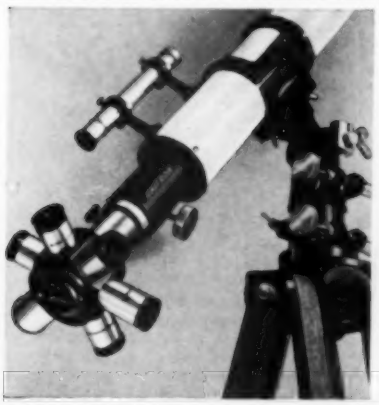

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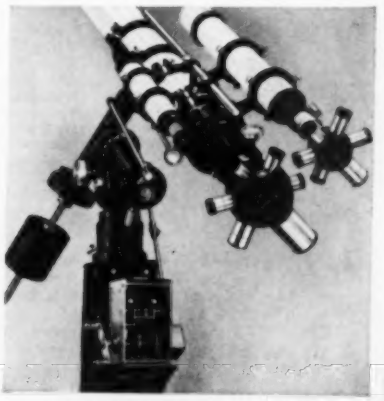

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Scientific Careers

(*Continued from Page 10*)

have vacancies in graduate assistantships in the sciences and not enough qualified applicants. Where are our Catholic graduates going? Some are going to medical schools it is true—but I am sure that not more than our proportional 10 per cent of the national figure.

I hope that you will not think that I am minimizing the contribution that Catholic schools are making to education in this country. Considering their recent origin and limited financial sources I think that all our schools are doing very well in the sciences as well as in other fields. If this is criticism, it is constructive criticism. I merely wish to call attention to the fact that more of our Catholic students should take up scientific careers. The next ten years will be years of opportunity for those students and for those schools that are alert to the changing times in which we live.

One thing to look for in the next year is a great increase in the number of fellowships and assistantships in all universities. The National Science Foundation will not only have its ordinary fellowship awards, but will greatly increase its Cooperative Fellowship Program, working directly through the universities. In this relatively new method senior students who wish to do graduate work may apply directly to the University of their choice. A number of Catholic universities will be included in the program along with others. The University will make its selection followed by another selection by panels chosen by the founda-

(*Continued on Page 32*)

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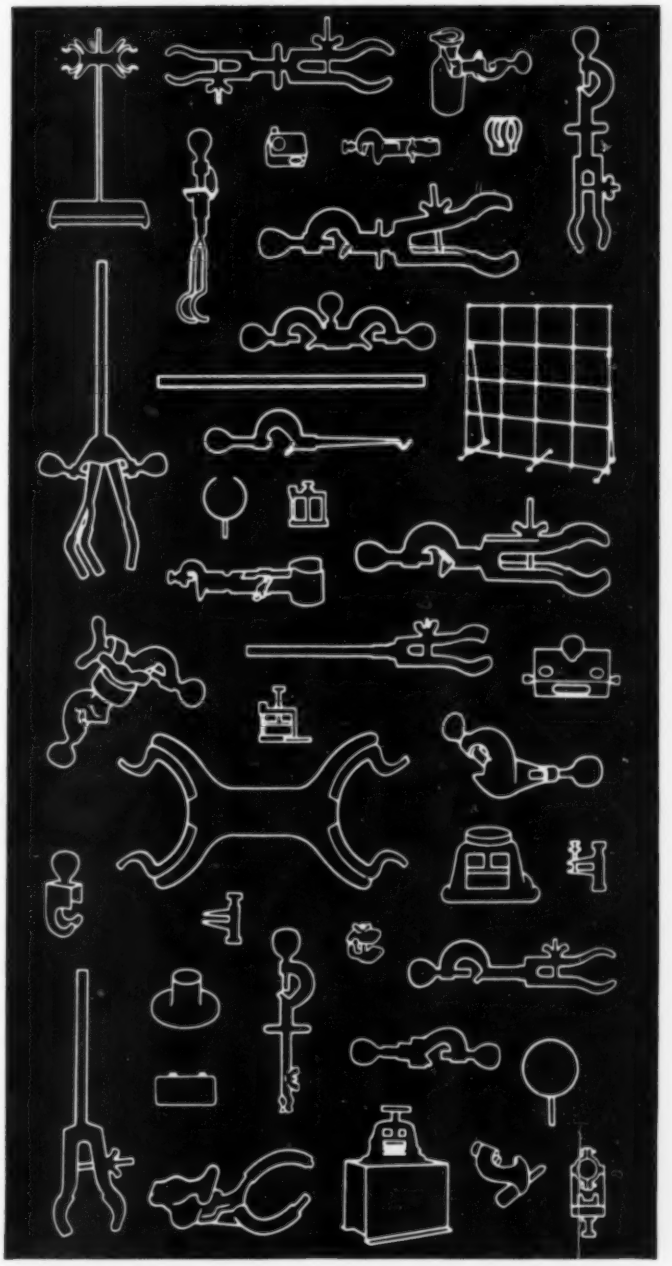

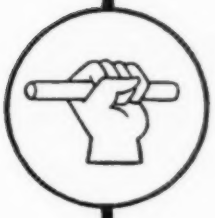

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Scientific Careers

(*Continued from Page 7*)

tion. The students finally awarded fellowships will have stipends to cover their living expenses and their tuition. Even those applicants who are unsuccessful need not worry about their expenses, because practically all of them will be able to obtain assistantships in some university. The need for graduate assistants to help with the rising enrollments of undergraduates will increase from year to year. There will be such a shortage of Ph.D.'s for years to come that from the time that a student starts his graduate work he will be able to finance his education without much trouble.

So much for the opportunities for our college students of today. We must go back to the secondary and even to the elementary school to find the factors that influence a student in choosing a scientific career. That is why so much attention is now focused on the high school teachers of science. All kinds of help for self-improvement and more effective teaching are now being offered to these teachers. This is to ensure that all high school students will know enough about biology, chemistry and physics to permit them to make an intelligent choice on entering college. For those who decide to study scientific subjects there is still a long way to go. Less than a quarter will probably persevere to become fully qualified scientists. Those who leave to take up other work will still have had the cultural benefits of some scientific training. Those who continue in the sciences will not only find ample rewards and satisfaction in their work but they will also be contributing to a phase of intellectual life which will have special significance in the next few decades. Our Catholic schools are dedicated to the full education of our young people with emphasis on religion and philosophy from the point of view of eternity but also with emphasis on the highest intellectual development of God-given talents for this life. Let us not allow the scientific talent entrusted to us to be diverted to less important activities. Rather let us help all our students achieve the full measure of their potential. Then it will follow that we will have as many of our graduates excelling in the sciences as in other phases of intellectual life.

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Text Books Come Alive

(*Continued from Page 30*)

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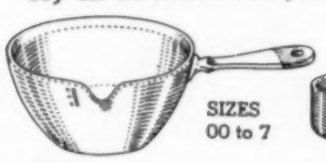

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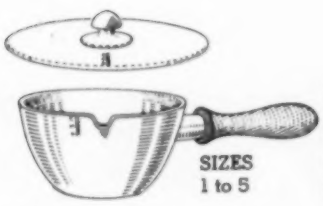

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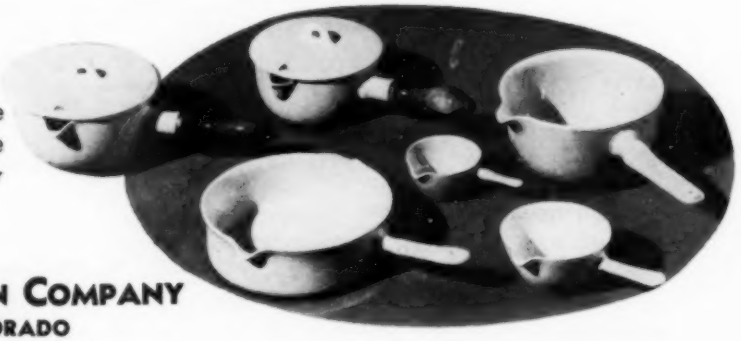

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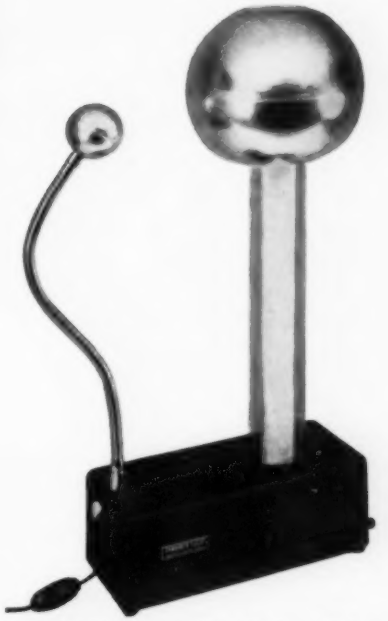

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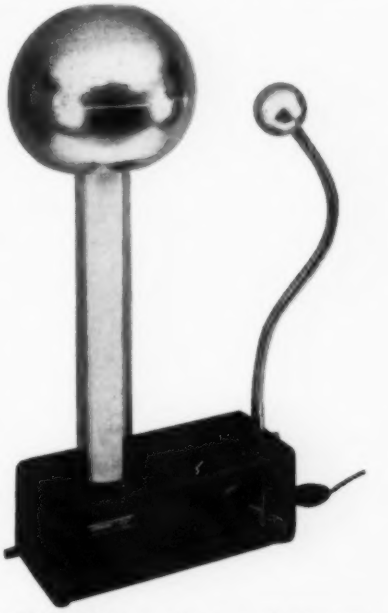

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